The Chemical Age

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The Chemical Industry in 1936

OPENING with the death of His Majesty King George V and closing with the accession of King George VI, following the abdication of Edward VIII, 1936 has exposed the industrial structure of the country to circumstances of unprecedented disturbance, but it has happily survived them and showed a determination to uphold the traditional British slogan, "Business as Usual." Under the new reign the barometer is set fair for continued progress in the chemical industry, but it is well to ponder Professor Thorpe's warning of the danger of showing preference to foreign inventions over British. As Dr. E. F. Armstrong remarks, we appear willing to honour the foreign inventor and to pay large sums in purchase and royalties for his inventions, but strangely reluctant to support British inventors or to encourage financially those discoveries which are struggling into the practical scale. This course is definitely destructive of enterprise and there is already evidence that it is having a harmful effect on the progress of our industry.

Notwithstanding a decided narrowing of the margin between exports and imports of chemical products, it cannot be denied that the British chemical industry has done pretty well in 1936. Its prospects for 1937, quite apart from the abnormal demands of defence work, are distinctly good; given a period of reasonably peaceful conditions the industry should achieve new records in the new year. The country is said to be becoming conscious of its chemical industry. Last month a leading London evening paper devoted attention to the prospects of work for the distressed areas in South Wales based on chemical manufactures. Attention was drawn to calcium carbide, not at present made in Britain, as the starting point for acetylene and the well-known series of synthetic organic materials which can be derived from this. The series is already made here and in sufficient quantity, but not the carbide. There is an immense potential industry to be based on the products of coal or of oil refining, the latter, alas! not a British industry. Industrial leaders have been persistent in reminding us that although we are enjoying a measure of prosperity, depression is inevitable sooner or later. The dangers of prosperity may indeed be as great as the dangers of adversity, but at this season of good cheer we may well leave to-morrow to take care of itself. On the morrow we shall be looking round to make certain that we are ready for the depression when it comes.

The Chemical Age wishes all its Readers, Contributors and Advertisers a Happy and Prosperous New Year.

Conditions in the heavy chemical industry are reviewed in other pages by Mr. P. Parrish, who points out that trade in 1936 has improved compared with 1935, which represented a distinct advance on the two previous years. This is confirmed by Board of Trade figures and by the increase of nearly 10 per cent. in the output of sulphuric acid in Great Britain and Ireland during the first half of the year as contrasted with the same period of 1935. More synthetic ammonia is being used for the production of nitric acid than for several years past and attempts to adjust the world demand for nitrogenous fertilisers to the possibilities of supply are proceeding apace. The quantity of concentrated gas liquor now being manufactured is something like 45,000 tons per year. Several works are dealing with more than 10,000 tons per annum and are manufacturing ammonia products at an economic price. Pressure processes for the production of ammonium chloride and sodium carbonate are gaining ground and increasing interest is being evinced in these processes.

In the past fertiliser year the consumption of ammonium sulphate in England, Wales and the Channel Islands increased by 3½ per cent. over the previous year; in Scotland by 0.7 per cent. and in Ireland by no less than 15.7 per cent., this large increase being doubtless due to the greater production of wheat and sugar beet in the Free State and to the better prices obtained for potatoes and grass seed in Northern Ireland. For the whole British Isles the increase in consumption was 4.9 per cent., compared with 0.7 per cent. for the previous year.

Although substantial progress has been made this year in the home market, the same cannot be said of the export trade. A decline of about 19 per cent. in export sales has been due to numerous influences that are now restricting foreign trade. Generally, however, the overseas Empire market is in a healthy condition. Exports of sulphate of ammonia to Australia have increased by over 86 per cent., to India and Burma by nearly 32 per cent., and to the West Indies, British Guiana and Mauritius by 36 per cent., so that it is possible that what we lose on the swings in foreign

countries may in time be recovered on the roundabouts of the Empire overseas.

There has been little radical change in the general position of the nitrogen industry during the present year; and Dr. E. B. Maxted, in his review of 1936, says the industry may now—in contrast to the conditions which obtained in it during the period of relatively rapid development of nitrogen fixation—be regarded as having attained a stabilised state in which the methods of production have become standardised and the potential output more than enough to satisfy the existing demands, at any rate under normal conditions. In his review twelve months ago Dr. Maxted mentioned, in connection with European exports, the construction of new nitrogenous fertiliser plants in the Far East; and this movement is apparently continuing. Further, among proposals for the manufacture of nitrogenous products in other countries, the proposed production of alkali cyanides in South Africa may be noted.

Considerable interest is being shown in adapting well-known fatty oils to new uses, in increasing the available supplies of fatty oils, and in devising substitutes for some which, owing to abnormal economic conditions or for other local reasons, are difficult to obtain in necessary quantities. The technical grades of olive oil have long held their position in certain textile industries in consequence of their capacity of not developing undue heat by oxidation when exposed to air in thin films on the textile fibre. Recent events in Italy and Spain have had a serious effect on imports of olive oil to this country, and intensive efforts are now being made, with the co-operation of the Wool Industries' Research Association, to find a substitute. It is said that the resultant saving to the wool industry might be as much as £120,000 per annum, and that already a product has been marketed which fulfils the requisite conditions. Useful and valuable work on fats and soaps is steadily carried on by committees of the Society of Public Analysts and of the American Oil Chemists' Society, by the International Commission for Fat Analysis and by other bodies in connection with the improvement and standardisation of methods of rapid analytical control of raw fatty materials and their products.

Intense effort on the part of the British textile industry to secure trade has been accompanied by a considerable amount of research into the scientific and technical problems which naturally arise in so complex an industry as that connected with textiles. For years the industry has struggled hard to capture a dominant share of the home market and to build up a large export trade such as it had before the war. As yet, it has been successful mainly in the home market; orders for export are exceptionally difficult to obtain. Yet at the present time our textile industry is definitely improving, especially in the rayon and wool sections.

Chemistry in the service of the community is nowhere more exemplified than in the work of the public analyst. In this sphere, Mr. Edward Hinks records that some 140,000 samples were examined by public analysts during the year, the results revealing 5.3 per cent. adulteration for the whole country. We must not, of course, draw the inference that it is a mere twenty to one chance that a food or drug we purchase will not be adulterated; the fact is that public analysts concentrate more or less upon cases likely to reveal breaches of the Food and Drugs Acts, and that the standard of purity is infinitely higher than the figures indicate. Public analysts are associated in their society with "other public analysts," and Mr. Hinks, as a public analyst, pays warm tribute to the "others" for their co-operation in devising methods of analysis. Analysis necessitates as much research as does any branch of chemistry.

History has been made in 1936 by the holding of the first international Chemical Engineering Congress in London under the auspices of the World Power Conference, the success of which was such that before the delegates dispersed they agreed to hold a second congress in Berlin in 1940. Over 80 per cent. of the officers and committee members were provided by the Institution of Chemical Engineers, whose members, in the week following the congress, accompanied the American Institute of Chemical Engineers on a week's tour of Great Britain. Judged on the results of its first year's work, the Chemical Council appointed by the three chartered chemical societies has shown itself to be an invaluable piece of co-ordinative machinery which can already point to successful achievements. Sir Gilbert Morgan wants to see a five-year plan for welding all the societies into a unified Chemical Society in time for that Society's centenary celebrations in 1941. Whether or not his ideal is realised there is no denying that the Chemical Council has made a good start which augurs well for the future.

Statistics published in the new 1937 edition of THE CHEMICAL AGE Year Book point to a general increase in the membership of chemical and allied organisations. Several of these societies have sent us reviews of their activities during the past twelve months, all of which indicate satisfactory progress. No fewer than 107 new members have been enrolled by the British Association of Chemists, whose recent annual report reflected the beneficial effects of sound administration combined with the results of improved trade. Its appointments bureau has been the medium for placing many good chemists in touch with appreciative employers, while its unemployment scheme—favourably commented upon by the Government committee entrusted with the investigation of the need for reforms in unemployment insurance generally—has fulfilled its functions to the advantage of a happily decreasing number of members. Dr. Vargas Eyre, the new president of the British Association of Chemists, points out that unless chemists in general and the younger generation in particular co-operate in developing a better professional spirit there is the danger of chemistry in industry becoming the sport rather than the guide of the politician, the financier and the business man. May the coming year bring a fuller realisation of these obligations.

Unfortunately we are not able, through exigencies of space, to publish in this issue the reviews of all the societies, but we hope to print next week the reviews of the British Association of Chemists, the British Plastics Federation, the Ceramic Society, the Chemical Society, the Colour Users' Association, the Institute of Plastics Industry, the Institution of Chemical Engineers, the International Society of Leather Trades Chemists, and the Society of Public Analysts. All of them support us in our belief that the new year will see an even greater advance than has been achieved in the year that is now closing.

Presidential Greetings

Professor N. V. Sidgwick
(The Chemical Society)

Dr. R. H. Pickard
(The Institute of Chemistry)

Lord Leverhulme
(The Society of Chemical Industry)

PRESIDENTS OF THE THREE PREMIER CHEMICAL ORGANISATIONS, 1936

The presidents of the three chartered chemical organisations have again favoured us with new year greetings and on this occasion we are also able to print a seasonable message from the president of the British Association of Chemists. The presidents of the Chemical Society and the Society of Chemical Industry refer to the progress made during the year towards co-operation through the medium of the Chemical Council.

The Chemical Society

DURING 1936 the Chemical Society has continued to pursue the objects for which it was formed some 96 years ago. In the message I sent to THE CHEMICAL AGE a year ago, I referred to the important step which had been taken towards co-operation between this Society, the Institute of Chemistry and the Society of Chemical Industry in entering into an agreement to form the Chemical Council, and stated that henceforth the future of the Society would be very closely linked up with that of the Institute of Chemistry and the Society of Chemical Industry. It is a particular satisfaction to me in my last year of office as president to refer to the valuable assistance that has already been afforded to the Chemical Society by the Chemical Council during the past year. As a result of the agreement that the three societies should contribute towards the maintenance of the library proportionately to their membership this Society has received during the year a substantial contribution to the library, and this has helped the Society to a considerable extent in supporting the burden of its publications. I am confident that such co-operation will continue in increasing measure to further the progress of the science of chemistry which this Society was formed to promote.

An important step the Society has taken during the year is to arrange for the publication, as from January 1, 1937, of British Chemical Abstracts "A" (Pure Chemistry) in separate sections, namely: A.I, Physical and Inorganic Chemistry; A.II, Organic Chemistry; A.III, Biochemistry; and to give Fellows the choice as to what sections they will receive. Apart from any possible economies that may result from this decision, it is a step which should be of assistance to Fellows in increasing their shelving accommodation and by saving the cost of binding.—N. V. SIDGWICK.

The Society of Chemical Industry

As President of the Society of Chemical Industry I would like to convey to readers of THE CHEMICAL AGE my Society's seasonable greetings and good wishes for the coming year. For fifty-five years the Society has been serving chemistry, both in its industrial and professional aspects, and it is with pleasure that I am able to report another year of successful achievement.

An event of major importance this year in the chemical world has been the first International Chemical Engineering Congress, which was held in London last June. The Society, as a whole, as well as its Chemical Engineering Group, played a considerable part in the planning and conduct of this congress, and it is therefore a source of gratification to us that its success was such that it has been provisionally decided to hold a second congress in Berlin in 1940.

The Society's annual meeting, held this year at Liverpool, proved an outstanding success, and attracted the best attendance that these meetings have had for many years, apart from those in which London has been the venue. At the invitation of our Yorkshire Section our annual meeting will take place at Harrogate next year. This will be the first time that the Society has met in Harrogate, and it is felt that such a happy choice should go far towards ensuring another successful meeting.

A feature of the Liverpool meeting was the presence of a large number of overseas visitors, outstanding among whom was an important delegation from the American Institute of Chemical Engineers. The majority of these visitors had just previously attended the Chemical Engineering Congress in London, and it is my belief that one of the most valuable things which the Society, and British chemistry in general, have gained during the past year has been the many inter-

national friendships, which have been made or renewed by British chemists as a result of the Chemical Engineering Congress and our own Liverpool meeting.

The Society is looking forward to further constructive achievement during the coming year. No doubt many people will be interested in the modifications which will shortly take place in the Society's publications. Beginning in January the Transactions, Communications and Abstracts, which are at present published weekly in the Journal, will be issued monthly as a separate publication. Unaltered in other respects, "Chemistry and Industry" will continue to appear weekly.

Undoubtedly the most significant development during the year has been the marked degree to which collaboration between the three senior chemical organisations has developed through the agency of the newly formed Chemical Council. Judged on the results of its first year's work, the Chemical Council has shown itself to be an invaluable piece of co-ordinative machinery, which can already point to some very successful achievements. The unified business control of all the publications of its member organisations is now vested in the Council, and it is also through its good offices that the burden of maintaining the library of the Chemical Society has been more evenly distributed among the other affiliated organisations, whose members make use of it. The Council has a great task before it, and the manner in which it has begun it augurs well for the future.

Industry is once again beginning to experience more prosperous conditions, and the Society hopes that this trade revival may be reflected in increased support for its work, a support upon which it must continually rely in order to maintain that high standard of service to chemistry, which is the purpose of its being.—LEVERHULME.

The Institute of Chemistry

I THANK you for inviting me to join you in an expression of goodwill to our fellow chemists at the end of the year. I do this gladly, but regret I cannot accept your further invitation to discuss the affairs of the Chemical Council in your journal. —ROBERT H. PICKARD.

British Association of Chemists

MUCH has been said and written lately about the part which chemistry plays in the community of interests making up the industry of the country: it has been pointed out frequently, and rightly so, that this is likely to become still more marked in the future as competition in prices and in quality grows keener both at home and abroad. The more senior industrialists, however, still look somewhat askance at this changed order of things, but accept the inevitable, whilst the younger generation err perhaps in taking risks based upon the possible turning up of some happy scientific solution of any difficulty. If no such solution or salvation is found in time, well, what to them is the use of science?

Generally speaking, the paths of scientific development in industry are ill-defined. When found, they are often long and difficult to traverse, but all the same, in the face of changing supplies of raw materials, new methods of manufacture and the demand for improved quality generally, a great change of attitude towards the trained investigator is quietly taking place. Progressive firms can no longer afford to be without those who are able to bring to bear and to apply scientific knowledge to industry, both on the manufacturing side and on the selling side. Up to the present this change has, for the most part, been brought about through the energy, enterprise and spirit of adventure of the trained chemist in industry: by his work is he known and by his work he has earned some measure of appreciation both of the industrial and of the academic section of his science.

Dr. J. Vargas Eyre, President of the British Association of Chemists.

Some time ago, being asked to speak at a gathering of artists, I drew a comparison between the chemist and the artist, the poet, the musician, and, indeed, all the creative professions. The media in which we work are different: they are different in each case mentioned, but in all of them there is necessarily the same creative urge, the same desire to achieve something, to reach some goal, a goal not always clearly seen, but comprehended in the mind through broad knowledge and understanding. In all this there is a striking similarity, always the great incentive to leave things better than they were found. Were it not so and chemistry did not offer such wonderful opportunities for the imaginative use of all kinds of existing knowledge, wherein would lie its charm? Chemists, like artists, are born, not made. They have an attitude of mind which develops through training and opportunity. Some get this at a university if they are fortunately placed with the right people; others get it in other ways either afterwards or through contacts and experience during industrial life. Like so many other professional men the chemist is, for the most part, his own teacher. It is surprising how many professional chemists of this kind, artists in their work, are to be found in industry to-day.

Be all this as it may, it is of the past. What of the future? But can one consider the future of the profession of chemistry without having regard to the past? We have inherited not only benefits, but obligations, from those who, with zeal and foresight, have given liberally of their time and money in furthering the best interests of our profession. Many have, by example, done much in this direction already, but much remains to be done, which can only be realised by lifting one's head above the petty jealousies of the day which tend to neutralise effort and obscure the view. Unless chemists in general, and the younger generation in particular, co-operate in developing a better professional spirit, there is the danger of chemistry in industry becoming the sport rather than the guide of the politician, the financier and the business man. May the oncoming years bring us a clearer and fuller realisation of these obligations and of our own duty in these matters. Let us remember that we must play our part, that we have obligations to ourselves and our colleagues as well as to existing chemical organisations and societies, all of which go to make up the corporate life of the chemical profession. Let the torch be passed on burning more brightly through our endeavours.—J. VARGAS EYRE.

GERMAN potash exports during the first seven months of 1936 totalled only 182,000 tons, as compared with 285,000 tons exported during the corresponding period of 1935. The value, however, rose to 7,630,000 marks from ,7330,000 marks. This situation is explained in part by the increased shipments to countries taking highly concentrated potash compounds and lighter takings on the part of countries accustomed to low-grade manure salts. Another factor of importance is the improved world prices for potash salts.

Chemical Industry Under the Reign of King George VI.

By Dr. E. F. ARMSTRONG, F.R.S., Ph.D., D.Sc., LL.D.

IT is tempting to draw comparison between the state of the British chemical industry at the beginning of the reign of King George V and the accession this month of his second son, King George VI. The change is demonstrable; to-day the industry finds itself well organised, co-ordinated for joint action and with the spirit of co-operation strongly developed. This is largely due to the success of the Association of British Chemical Manufacturers and the individual work of a series of chairmen and the two general managers.

The industry has State assistance in the form of the Dyestuffs Act, the Safeguarding Act and the general tariff. It is in close contact with and has the support of all the departments of State. The barometer would thus appear to be set fair for its continued progress. It must depend on the leaders of the individual firms as to how far a vigorous and progressive policy is prosecuted so that this country is able to manufacture its own requirements on a truly competitive basis, to engage in the export trade and to keep abreast with the development of new products and new processes.

Another factor making for success is the existence of a large body of trained chemists, as well as facilities for teaching chemistry at the universities. Opinions may differ as to the practical nature of the training, but this is not a subject for discussion here. What is necessary and largely lacking is some appreciation of the need of a greater knowledge of science by the layman, in particular by executives, so that they may at least understand the potentialities of the industry.

Give the British Inventor a Chance

A serious defect to-day, to which attention has more than once been called, notably by Professor Thorpe in his presidential address to the Institute of Chemistry, is the preference shown to foreign inventions over British. We appear willing to honour the foreign inventor and to pay large sums in purchase and royalties for his inventions, but strangely reluctant to support British inventors or to encourage financially those discoveries which are struggling into the practical scale. This course is definitely destructive of enterprise and there is already evidence that it is having a harmful effect on the progress of our industry. If any one doubts what we have stated, a few weeks spent among the chemical industries in the United States will go far to confirm its correctness. Chemical industry there is a hot bed of activity; over 18,000 chemists belong to the American Chemical Society and all are busy on new uses for chemicals, new processes for making them—often on the largest scale, and the discovery and manufacture of new chemicals. The university laboratories are in the closest touch with practice. Another custom of many firms in the United States, which we should like to see receive consideration here, is the submission of their research programmes quarterly to outside experts who act in a confidential consultative capacity. It is claimed that this plan is providing excellent results.

The possibility of co-ordinated research to prevent duplication of effort has already been put to the fine chemical industry in connection with the continuance of the Safeguarding Duties, but it is difficult to see how this could be a practical success in an industry in which the basis is scientific research. Research associations are necessary in industries where fundamental knowledge is lacking, but have no place in the peace-time organisation of competitive firms in the chemical industry.

Dr. E. F. Armstrong, President of the Association of British Chemical Manufacturers.

Reference may appropriately be made to certain co-operative movements within the industry which are proving highly beneficial, though their immediate effects are perhaps not always realised in the board rooms. Their advantage is, in part, that they anticipate and therefore postpone legislation. This applies in particular to the work on safety, which came under discussion as an international topic at the International Chemical Engineering Congress held in London this year. This is covering an increasingly wide field in its application, and the chemical industry can claim not only to be ahead of any other in this respect, but also to have discovered how to work in the utmost safety and unconcern with materials which otherwise might be very dangerous. A problem arises when some materials pass into wider consumption and an ignorant public has to learn how to use them properly.

The same public only learns with difficulty that knives cut and petrol burns fiercely; the fact that some chemicals are corrosive and others are toxic or induce dermatitis will be equally hard to convey to it, and it is at least certain that the knowledge cannot be forced on the public by panic legislation.

The Standards Movement

The industry is benefiting also by the adherence to the standards movement, the value of which is being increasingly demonstrated as confidence is being gained and the application of standards extended. A great deal of co-operative work is being put into this subject, which will undoubtedly yield a rich harvest of results within the next decade.

Perhaps of more immediate value is the work on traffic problems concerning the rates and conditions of transport which affect the whole industry. Internal traffic is in a state of flux; goods are carried by rail, road, canal and coastwise shipping under a variety of regulations. The whole question is under study by the Transport Advisory Council constituted by the Minister of Transport. Traders are concerned to see that transport is adequate, safe and inexpensive and that no burdensome restrictions are imposed on the ancillary road user. By the Acts of 1930 and 1933 the public carriage of goods by road is virtually closed to new entrants. Peculiar to the chemical trade to a large extent are the methods of packing and shipping chemical merchandise of various descriptions.

The chemical industry has as yet hardly experienced the effect of rearmament, apart from the influences of this factor on the general trade. It will undoubtedly do so in the near future and much reorganisation seems necessary to fit it for the great tasks which will be imposed on it should conditions become serious. The peace industries should look ahead to find alternative or independent sources for many chemical

materials which might then become unavailable. Such planning may appear ridiculous to-day, but the industry will lay itself open to harsher comments if it neglects such an obvious duty. Both in attack and defence, chemicals are of far greater importance than any politician or leader of a fighting service is able to realise. There is not a single munition of war for the manufacture of which chemicals are not used at some stage or other. Moreover they will be wanted quickly and by everybody. With all this in mind, we would put the need to have the industry organised for defence as the most urgent problem awaiting it in the new reign.

Conditions on the Continent

The fact cannot be overlooked that in Germany to-day the pursuit of pure knowledge has been largely abandoned and the chemical forces are largely or wholly occupied in working for the State, either from the military point of view or from the more general aspect of making the country economically self-supporting by providing alternatives or substitutes for materials previously imported from abroad. The achievements in textiles, in rubber, in oil, to mention only three, may be cited in this connection. Equally significant is the remarkable achievement of the Italian chemists and chemical industry during the period of sanctions: the speed at which it has been performed makes the deed all the more meritorious. The chemical industry is developing rapidly in other countries, notably Japan. It is desirable that the home industry should be fully cognisant of what is happening and not be content to take refuge behind the advantages given to it at home by legislative enactions.

It is disconcerting to note, as was emphasised by Mr. Wallace at the annual meeting of the Association of British Chemical Manufacturers, that there is a steady increase in the imports of chemicals, drugs, dyes and colours since 1933, notwithstanding the fact that the bulk of these imports are in respect of products for which there is adequate production in this country.

It is undesirable to refer to the efforts and achievements of individual firms in the industry, even in relation to new developments, though it is appropriate to mention in passing such progress as the new plants for making such diverse products as phenol, potassium chlorate, potassium permanganate, titanium white and magnesium. It is probable also that the next few years will see developments in the recovery and use of sulphur from fuel gases, all of which is at present wasted.

Future Trend of The Industry

The possible future trend of the industry is indicated by a study of the patent applications. Magnesium is the favoured metal, no doubt because of the application to aircraft. Chlorinated rubber for coating compositions and rubber threads suggest new lines of development: someday latex will be regarded as a chemical raw material. Artificial resins continue in the forefront, particularly the vinyl polymerisation products. There is much patent activity in connection with vitamins, enzymes and hormones, particularly the sex hormones: the day is not far distant when synthesis will make such products a commonplace.

There is still a crop of inventions relating to the use of wetting or surface tension reducing agents, consisting of long chain aliphatic residues combined with other residues. A notable increase in inventions relating to organic chemistry calls for comment and makes it probable that these industries will tend to expand materially in the near future.

The old-fashioned method of measuring the prosperity of the industry was based on the production of sulphuric acid. Friends of the late Sir Max Muspratt will recall with sympathy his little orations on this subject. In this respect 1936 shows a gratifying increase over 1935 and still more over 1934, on the figures for the first six months. One is tempted to wonder how long it will be before the word "shortage" is used in connection with this chemical.

There are pleasing indications that the country is becoming conscious of its chemical industry. Last month a leading London evening paper devoted attention to the prospects of work for the distressed areas in South Wales based on chemical manufactures. Attention was drawn to calcium carbide, not at present made in Britain, as the starting point for acetylene and the well-known series of synthetic organic materials which can be derived from this. The series is already made here and in sufficient quantity, but not the carbide. There is an immense potential industry to be based on the products of coal or of oil refining, the latter, alas, not a British industry.

Opportunities in the Building Trade

Allusion should be made to the great opportunities in the building trade for what may fairly be termed synthetic chemical products. The industries making these are basically chemical though the public does not so regard them. Progress of the kind which we are about to indicate will depend on the abandonment of the time-old conservative ideas with regard to house building. These die hard, but the need for low-priced construction and labour-saving devices is forcing change all the time. The cement industry is prospering, its opportunities are greater than ever. Stainless steel continually finds new uses: its price limits it to some extent, but before long it should be cheapened. Glass, either toughened or made transparent to health rays, is a chemical product, as are the vitreous materials available for bathroom and kitchen. Plaster boards are deservedly popular, whilst the synthetic plastic products are always serving additional uses in the home. Tubular furniture makes use of new alloy steels. Rubber in novel forms must have uses yet to be discovered.

The Pharmaceutical Society

Education System to be Reviewed

DURING the year the remaining provisions of the Pharmacy and Poisons Act, 1933, have come into operation. On January 1 the statutory disciplinary committee acquired its powers of removing the name of a pharmacist from the register and of disqualifying a body corporate from acting as an authorised seller of poisons. Three disciplinary cases have been considered by the committee. The new register of premises of authorised sellers of poisons, containing the addresses of 13,800 premises, was published in August. The Poisons Rules, 1935, came into force on May 1, but until December 31 the labels and containers used in the sale of poisons may conform to the old requirements. Under the rules a number of drugs, including the barbituric acid group of hypnotics, may be supplied to the public only in accordance with the prescription of a medical practitioner.

A committee has been appointed by the Society's council to review the whole system of education and training of pharmacists and to make any necessary recommendations.

The first revision of Volume I of "Martindale's Extra Pharmacopœa" since its acquisition by the Society is now almost completed, the revised Volume II having been published during 1935. As a result of the wide use of the "British Pharmaceutical Codex" in India and the Dominions the Codex Revision Committee has under consideration a plan for consultation with pharmacists throughout the Empire on matters arising out of the reationship of the Codex to the Dominions.

The Pharmaceutical Society has taken part in negotiations on possible defensive measures in the event of gas attack in this country, and the Society has been in consultation with the Home Office in connection with the elaboration of a scheme for the recruitment of gas detection officers. A large number of original contributions have been published from the Society's College, including papers on biological methods of estimating extracts from the suprarenal cortex, and on the relationship between the chemical constitution and the therapeutic properties of aromatic amino-ketones and amino-alcohols.

Conditions in the Heavy Chemical Industry in 1936

By P. PARRISH, F.I.C., M.I.Chem.E., M.I.Gas E., F.I.I.A.

Mr. P. Parrish, Manager of the Chemical Works of the South Metropolitan Gas Co.

THAT trade in the heavy chemical industry in 1936 has improved, compared with 1935, which represented a distinct advance on the two previous years, is certain. This is confirmed by Board of Trade returns, and by an increase of nearly 10 per cent. in the output of sulphuric acid in Great Britain and Ireland during the first half of this year, as contrasted with the January/June period of 1935.

The death of Sir Frederick Norman occurred this year. He was manager, for fifty-seven years, of Wiggs' Chemical Works, at Runcorn. Sir Frederick advised Matheson, the founder of the Rio Tinto Co., Ltd., when he explored the possibilities of Rio Tinto, and claimed cupreous pyrites as the cheapest form of sulphur for acids and sulphates. He had notice from Disraeli for his part in the expansion of the superphosphate and allied industries, that followed as a result of his giving the alkali trade cheap sulphur.

Synthetic Ammonia Industry

Attempts to adjust the world's demand for nitrogenous fertilisers to the existing superabundant possibilities of supply appear to be proceeding apace. More synthetic ammonia is being used for the production of nitric acid than for several years past. Many nitric acid plants have been erected in Europe during the current year. The processes available are the Bamag, Fauser, Frischer, Hydro-Nitro, Pauling and Du Pont.

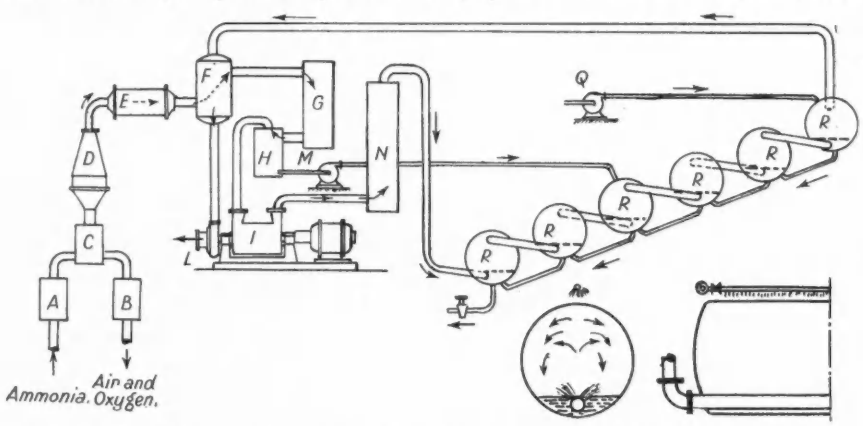
Which should be installed? This depends upon a number of considerations, chief of which is the availability or otherwise of cheap oxygen, cheap power and whether a compact plant of unusual symmetry is sought.

The Hydro-Nitro process uses oxygen to enrich the air-ammonia mixture, compresses to 5 atm. and employs a multiple-gauze converter (about twenty gauzes) absorbing the oxides of nitrogen, which need a certain amount of oxidation, in a single bubble-cap tower made of Staybrite. The consumption of platinum is reported to be high with this method.

Fauser enriches the air to 24-25 per cent. oxygen and, contrary to the Hydro-Nitro or Bamag processes, compresses the oxides of nitrogen, using a series of tanks arranged in cascade as the absorption apparatus. By this means a relatively inexpensive system of absorption is established. The costly packing of the old form of absorbing towers, with their concomitant disadvantages, is dispensed with. Fig. 1 gives a diagrammatic view of a Fauser nitric acid plant with a detail of the absorption unit.

With the Hydro-Nitro and Fauser processes nitric acid of 60 per cent. HNO_3 is manufactured, and invariably needs to be concentrated to 94 per cent. HNO_3. Fortification can be effected by the use of strong sulphuric acid, which is fed in suitable proportion with the nitric acid, 60 per cent., to a denitration tower. If steam is used to the extent of 80 per cent. externally, and only 20 per cent. internally, as is the case with the Frischer process, the quantity of dilute sulphuric acids produced is reduced materially. This method of fortifying the nitric acid, from 60 per cent. to 94 per cent. or even higher, demands an efficient form of sulphuric acid concentrating plant.

It is the view of some chemical engineers that the Gaillard and Kessler concentrators are not suitable for this specific duty. The writer has given some consideration to the problem, and has reached the conclusion that what is demanded is an apparatus incorporating a cast iron pot, or pan, with or without stirrer, provided with a specially arranged dephlegmator, in which fractional condensation can be effected, under rational conditions—preferably under vacuum. The cast iron pot should be specially seated and can be heated by oil, producer gas, or even direct fired. Fig. 2 shows this form of concentrator diagrammatically, and Fig. 3 shows two views, one of the pot-platform, with stirring gears and dephlegmators and the other of the cooler stage. Fig. 3 shows a plant erected by Pauling.



A and B.—Gas Filters C.—Mixing Chamber D.—Oxidising Chamber E and F.—Heat Exchanger G.—Condenser H.—Condensate Tray I.—Compressor L.—Turbine M.—Pump N.—Oxidation Tower Q.—Pump R.—Absorption Cylinders

Fig. 1.—Fauser nitric acid plant, showing novel absorption system.

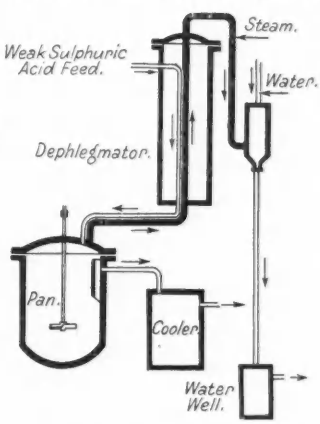


Fig. 2.—Acid Concentrator.

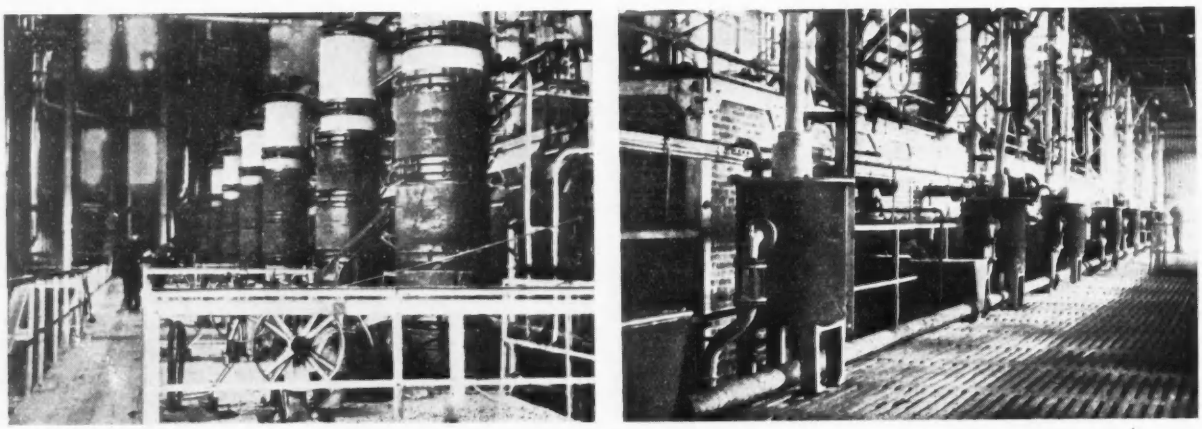


Fig. 3.—Special form of sulphuric acid concentrating plant, showing (left) pot platform, with stirring gears and dephlegmators, and (right) the cooler stage.

Where power is cheap, Fauser usually increases the concentration of nitric acid from 50-60 per cent. HNO_3, to 96 per cent. HNO_3, by employing pure oxygen in an autoclave, at a pressure of 50 atm.

At the recent research meeting of the Institution of Gas Engineers, reports for the last twelve months were presented. The research work in question has been conducted in conjunction with the University of Leeds and the Fuel Research Board. Several matters of importance have emerged. It has now been declared that sulphur must be removed from coal gas. Dr. Charles Carpenter realised the necessity for this twenty-two years ago, and hence the Carpenter-Evans catalytic process for the removal of CS_2 from coal gas was adopted at the several works of the South Metropolitan Gas Co.

The Gas Industry's Problem

The elimination of sulphur from coal gas will afford gas undertakings an opportunity of competing for space-heating. A "flued" heater enables 50 per cent. of the potential heat of the gas to be employed; a flueless heater enables 90 per cent. of the heat to be used. But such a heater cannot be supplied with impunity until a sulphur-free coal gas is available.

The view has been expressed that the domestic shovel for solid fuel will disappear; that sooner or later the problem of the synthesis of methane and allied hydrocarbons, from carbon monoxide-hydrogen mixtures, will be solved, and will enable gas to be sold at such a price as to displace solid fuel. It has also been urged—and this view doubtless represents that of the coke oven interests—that the iron and steel industry must have the best coking coal, or its efficiency will diminish. There are apparently only limited supplies of coking coal in this country, and only very limited supplies of first-class coking coals. It is suggested by the last-named interests that a non-caking coal has the advantage of a very combustible coke, if treated in the right way.

What is interesting is that Professor Fischer has declared recently that if the temperature of the Fischer-Tropsch reaction is allowed to become too high, instead of producing oils the product is largely methane. The proposal under consideration by the gas industry is one relating to some form of Fischer-Tropsch reaction, applied to water gas, using oxygen in lieu of air, and obtaining a synthetic gas consisting largely of hydrogen and methane (with little, if indeed any, carbon monoxide), having a calorific value similar to that of the coal gas now sold.

Will the future see a modified total gasification process, involving catalysis, with or without high pressures, superseding the present gas-making method?

Meanwhile, the production of semi-coke continues to grow, as is revealed by the following statistics, copied from the report for 1935 of the Secretary of Mines.

	Unit.	1932.	1933.	1934.	1935.
		(i) Total quantities.			
Coal distilled	tons	222,616	317,703	284,242	327,112
Products:					
Semi-coke	tons	162,797	222,245	220,793	260,358
Gas*	1,000 cu. ft.	1,287,000	2,112,195	1,479,900	1,658,006
Tar	gal.	3,091,537	4,899,820	4,693,832	5,298,404
Crude spirit from gas ..	gal.	429,755	741,177	767,438	878,079
		(ii) Production per ton of throughput.			
Semi-coke ..	cwt.	14.6	14.0	15.5	15.9
Tar	gal.	13.9	15.4	16.5	16.2
Gas	therms	32.1	34.4	33.3	32.3
Crude spirit from gas ..	gal.	2.16	2.68	2.89	2.93

This month will witness the inauguration of another installation of low temperature plant, at Bolsover, capable of carbonising about 168,000 tons of coal per year.

Pipe stills are likely to prove an advantage for the distillation of coal oil, because they ensure (a) minimum operating costs as regards labour; (b) close-cut fractions; (c) economical heating; (d) reduce decomposition of the coal oil to a minimum; and (e) allow of renewals being effected without any dislocation of the setting. Moreover, it is conceivable that the quantity of pitch produced can be reduced considerably, if suitable control obtains. Flexibility of this order is an advantage, especially when the demand for pitch is sluggish.

Pipe Stills for Coal Oil

The foregoing views of the author appear to be confirmed in an interesting contribution by Dr. H. G. Shatwell, concerning "Methods of Coal Tar Distillation"[1]. Indeed, Dr. Shatwell remarks: "By this means, many laborious refractionations of the tar acids would be avoided, and, at the same time, a higher production of naphthalene would be assured, because it would be concentrated in a comparatively small bulk of oil. From the closely-cut hydrocarbon fractions remaining after removal of acids and bases, commercial grades of solvent and heavy naphthas, benzene, toluene, xylenes, motor-benzol, light and heavy creosotes and anthracene could be prepared with greater ease than is possible by current methods of distillation at the crude tar-stills."

Ammonium Salts

Continental manufacturers using synthetic ammonia in the manufacture of sulphate of ammonia apparently still find it necessary to cover methods for producing coarse crystals. This is evidenced by the invention of the I.G. Farben-

* The yield of gas varies widely in quantity according to the process and the kind of coal treated.

Spirit is not "scrubbed" from the gas at all plants. These figures are related only to the plants where crude spirit was extracted from the gas produced.

industrie. A product having a large pore volume, and excellent capacity for being stored, is obtained by carrying out the crystallisation in the presence of dissolved aluminium salts—0.003 to 0.7 parts as Al_2O_3 per thousand of the dissolved ammonium sulphate, while maintaining a *p*H value from about 5.8 to 7. Other details will be found on reference to Brit. Pat. 445, 120 (1935).

Again, another process is covered by Brit. Pat. 440,807 (1934). It has been found by the I.G. Farbenindustrie that even when working in a neutral or alkaline solution it is possible to increase the size of the ammonium sulphate grains by means of slight additions of dissolved metal salt, a complex metal compound, or an organic sulphonic acid, not exceeding about 1 per cent., calculated on the ammonium sulphate present in the solution. It is reported that crystals 1.5 mm. in thickness and 2 mm. in length are being obtained (ratio of thickness to length, 1 : 1.33).

The author has never found any difficulty in producing large crystals, when using either gas liquor, or mixtures of concentrated gas liquor and gas liquor, or even synthetic ammonia provided the saturator is designed in a certain way, and certain conditions are observed. Where ammonium sulphate solutions have to be evaporated, the evaporator must be designed specially, and certain conditions of working complied with.

A considerable amount of heat is involved in neutralising strong, or medium-strength, inorganic acids with ammonia. This heat may be utilised for concentrating the solutions of the salts formed. When producing solid ammonium nitrate from nitric acid and gaseous ammonia, difficulties are encountered in utilising the liberated heat, by reason of the volatility of the nitric acid at high temperatures. It has been proposed to effect combination of nitric acid and ammonia in the gaseous phase, in order to avoid loss of nitric acid.

By an invention[2] of Bamag-Meguin A.-G., nitric acid solution and gaseous ammonia are intermixed in the finest possible division, with boiling ammonium nitrate already formed. Combination of the two components is effected in the liquid phase in the lower part of the saturator, containing the fused mass. To avoid loss of nitrogen through escaping nitric acid, not only the ammonia, but also the nitric acid is conveyed by pipe-lines to the lower part of the fused mass. Other details of interest are described in the specification.

Arsenic

The demand for insecticides of plant origin, such as pyrethrum and derris product, has of recent years been a progressively expanding one. Whether compete replacement of arsenical preparations, even if it should eventually prove to be economical and technically feasible, will result cannot as yet with any degree of certainty be said.

The consumption of white arsenic in this country and the colonies is greater than it was several years ago, since the use of sodium arsenite is growing as an agent for combating the locust plague in South Africa and elsewhere. Further lead arsenate has still to meet a really serious competitor in the fight against insect pests, in many branches of tropical and sub-tropical agriculture. Sweden is the key to the international arsenic position, as arsenic is produced in large quantities in the recovery of gold from complex ores, largely by the Bolidens Mining Co. At present it is understood that Swedish arsenic is being stored, pending better prices.

By-Product Ammonia

The quantity of concentrated gas liquor now being manufactured is of the order of 45,000 tons per year. Several works are dealing with more than 10,000 tons per annum, and are manufacturing ammonium products at an economic price.

Three types of plant have been evolved for the treatment of gas liquor. One manufactures a product containing 15 to 16 per cent. of ammonia by weight. Another, involving partial decarbonation of the gas liquor, so controls the steam, ammonia and carbon dioxide stream to the condenser, that despite an unfavourable $CO_2 : NH_3$ ratio in the gas liquor, a product containing 20 per cent. of ammonia by weight can be manufactured with a steam consumption of about 20 per cent. by automatic means. This process is covered by Brit. Pat. 449,347.

The two foregoing methods merely deal with the free ammonia of the gas liquor. National exigencies may demand a process for dealing with both free and fixed ammonia. Indeed, such a plant has been installed, and is producing concentrated gas liquor of 20 per cent. ammonia by weight. It is known, from the experience of this plant, that by the adoption of a special liming arrangement, production could be rendered automatic.

The chemical constitution and behaviour of the concentrated gas liquor still require further elucidation. It is known that ammonium hydrate, at certain concentrations, depresses the solubility of other ammonium salts of the concentrated gas liquor, in conformity to the rule that a substance introduced into a solution with another solute, without reacting with it to form any complex ions, commonly decreases the solubility of the solute.

Disposal of Effluent Liquor

One of the difficulties in the extension of the production of concentrated gas liquor is the disposal of the effluent liquor. This obstacle will doubtless be overcome when Lord Gainford's Bill is placed on the Statute Book. Local authorities will then be required to accept trade effluents, of which spent liquor from a gas liquor distillation unit is one.

Meanwhile, nothing but good can result from the removal of the fixed ammonia. It is known that the biochemical oxygen demand of a sewage is adversely affected by ammonia in any form. Indeed, the removal of the fixed ammonia, under certain conditions, is of more importance than the removal of phenols, since the latter does not appreciably improve the facility with which an effluent liquor can be treated at a sewage works.

The author has prepared a series of cost sheets, intended to elucidate and emphasise (a) the importance of producing a satisfactory quality of gas liquor, (b) the influence of fixed ammonia on the ultimate cost of production of concentrated gas liquor, and (c) what is the relative position of recovering all the ammonia (free and fixed), as contrasted with the free ammonia only, in the manufacture of concentrated gas liquor, in the automatic plants of the Thorncliffe-Baldurie type. The following table gives a summary of the position, and constitutes information of a novel character.

RELATIVE COSTS, PER UNIT OF AMMONIA, IN MANUFACTURING CONCENTRATED GAS LIQUOR WITH VARYING QUALITIES OF GAS LIQUOR.

Gas liquor containing	Total ammonia removed. Cost per unit of ammonia.	Free ammonia only removed. Cost per unit of ammonia.
	d.	d.
1% ammonia : 30% fixed ..	10.0	9.45
2% ammonia : 30% fixed ..	7.9	6.00
3% ammonia : 30% fixed ..	6.9	4.65
2% ammonia : 20% fixed ..	7.3	5.40

Sulphur

Much was written in last year's review on the subject of the recovery of sulphur from metallic sulphides, and other crude materials. One has reason to hope that the efforts now being concentrated on the recovery of sulphur from crude materials—sulphide ores and waste gases—will lead ultimately to more favourable prices obtaining for sulphur.

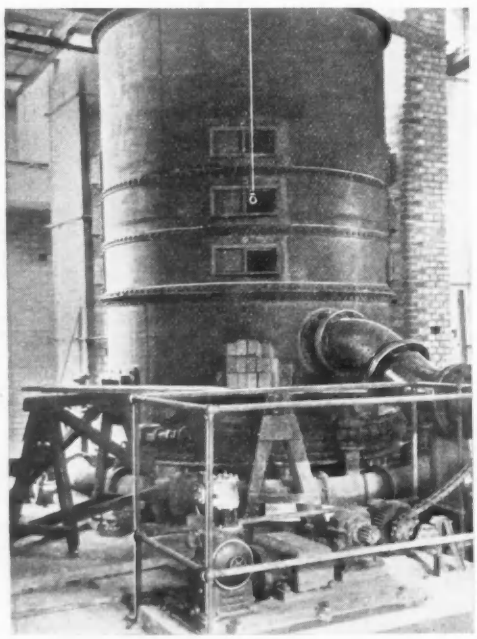
The U.S.S.R. have investigated several processes. Pyrrhotine (which contains 15 to 42 per cent. of sulphur), is calcined in a current of hydrogen, and H_2S is recovered, to the extent of 96.6 per cent. of the sulphur content. By replacing hydrogen by steam, superheated to 300° C., about 95 per cent. of the sulphur was recovered—60 per cent. as H_2S, and 35 per cent. as elemental sulphur. By passing over the ore under calcination a mixture of steam superheated to 300° C., and a current of air, 96 per cent. of the sulphur was recovered—60 per cent. in the form of the element.

In connection with the recovery of sulphur from waste gases, the fundamentals of the production of sulphur from SO_2 by thermal reduction have been discussed.[3] It is stated that the consumption of coke per ton of sulphur made is only one-fifth of a ton, when working with 100 per cent. SO_2, whereas with roaster gases containing 3 per cent. of SO_2/vol., and 13 per cent of oxygen, the consumption of coke may reach thirty-three times the weight of the sulphur made.

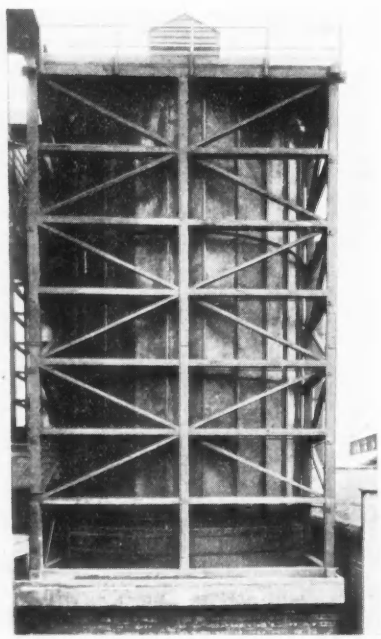
In the above connection, it is interesting to note that the use of xylidine has been developed by the Lurgi Gesellschaft, of Frankfurt. It is reported that they are busy with the erection of a plant at a foreign lead smelter for a daily recovery of 30 tons of sulphur dioxide from roaster gases of 4 per cent. SO_2 by volume.

Details concerning the sulphidine process[4] should be studied.

It should not be overlooked that this country was responsible for the pioneering work in developing a practical process for utilising the carbon reduction reaction on metallurgical gases. M. P. Appleby's (I.C.I.) account of the use of sodium sulphite and aluminium chloride as an absorbing medium for gases containing weak concentrations of SO_2 is still fresh in one's memory.



Left.—Fig. 4.—Hydrogen sulphide burner.



Right.—Fig. 5.—Gaillard Parrish recent cheap form chamber of tower construction.

Sulphuric Acid

The importance of the use of waste gases containing H_2S up to 25 per cent. as a raw material in the manufacture of sulphuric acid has been stressed. Plants have been erected in London, and it is certain that more units of this kind will be installed.

One of the difficulties encountered at one works is the variation of the H_2S content. In order to overcome this difficulty a process has been covered,[5] by which the use of a residual product from the distillation of benzole hydrocarbons, containing a high concentration of carbon bisulphide, namely, concentrated benzole forerunnings, has been found to be advantageous. This method is especially adapted to plant of the contact type, since the impurities associated with the carbon bisulphide are likely to render the chamber process difficult of operation.

Fig. 4 shows an H_2S burner, in connection with an installation that is producing about 100 tons per week of acid, by a modified nitration process, at an incredibly low cost. Means for maintaining the H_2S of reasonably constant composition can be adopted, and, simultaneously, a profitable product manufactured.

At the Chemical Engineering Congress held in June last, interesting contributions were made concerning the manufacture of sulphuric acid in Japan and Russia. Both the nitration and contact processes were referred to. It is interesting to note that the first tower system installed in Japan was the Opl, in 1914. Later, G. Osame has developed his own special form, where several towers are connected *en bloc*.

Reference has been made[6] to the operation of the Gaillard-Parrish system, as applied to rectangular chambers. Acid from the back chambers is first cooled, then sprayed by turbo dispersers into the front chambers. The necessary water for reaction is introduced along with the acid *via* the dispersers. By this method, it is remarked that the gases are thoroughly mixed, and are continuously bombarded with a cool acid mist, thus increasing the speed of reaction, and promoting condensation. This method can be used in connection with any type of rectanguar chamber, and enables this form to be operated at 4 to 5 c. ft. per lb. of sulphur per day.

With a view to cheapening the cost of the construction of Gaillard-Parrish tower chambers, a wooden framework, of pitch pine, has now been developed, the lead sheets being supported from a Z steel ring at the top, from which depend minor vertical members, as is made clear in Fig. 5. Leadwork arranged in the form shown costs for labour about £5 per ton to erect. A still cheaper form has been evolved, using the same type of pitch pine framework (a steel framework can be employed where desired), but using an octagonal Z-steel ring. With this form of chamber, all the advantages of circular construction are obtained. There is no need for the dressing of the lead to a circular shape: the construction is simplified, and the leadwork can be erected complete, as regards labour, for about 50s. per ton.

The Moritz system of sulphuric acid plant construction has been described and illustrated, and particulars of the plant erected at King's Lynn were published in THE CHEMICAL AGE, November 1, 1936, page 431.

Reference has been made earlier in this review to the need for some improved sulphuric acid concentrator for weak acid, about 70 per cent. H_2SO_4, arising in the process of the fortification of weak nitric acid. What meets requirements has already been indicated. In this connection, however, it is interesting to remark that direct-fired acid stills, constructed

entirely of thin tantalum sheet, have been in actual production service for some two years now in the United States, with satisfactory results. It is necessary to keep the floor of the vessel free from sludge and caked deposits. Storage tanks have been lined with tantalum, over the region of usual acid-air-interface, while the metal in question has been found a distinct economy for acid evaporator pipes in the chlorination and sulphonation of oils.

Valuable information has been published[7] about the application of lead and its alloys in chemical engineering practice. This contribution is unique, and has been published in brochure form. It is interesting, in this connection, to note that tellurium is being recovered from the dust from electrostatic precipitators at a superphosphate works at Odessa. The steps comprise treatment with hydrochloric acid, oxidation with potassium chlorate, and precipitation of the tellurium by sulphur dioxide. With a dust containing 0.24 per cent. of tellurium, 40 per cent. of the element is recovered. The chlorine-treatment process is being developed, as it is believed that such method will prove more economical than that now being worked.

The Bolidens Mining Co. has covered a process[8] for the refining of selenium. Selenium is used, along with nickel, to the extent of 0.015 per cent., for reducing the grain size of a German chemical lead—Edelblei.

Alkali Industry

Pressure processes for the production of ammonium chloride and sodium carbonate appear to be gaining ground. At all events, increasing interest is being revealed in these processes.

A warning was issued in January last about chlorine-caustic soda balances. In the United States the relative market positions of caustic soda and chlorine have undergone a marked change in the past four or five years. At one time the disposal of chlorine was an economic problem: to-day, caustic soda is more difficult to sell. For this reason, the industrialisation of a process depending upon the reaction between nitric acid and salt, for the production of sodium nitrate and chlorine, has been decided upon. This process has also been considered in Europe.

The direction in which development of electrostatic precipitation is advancing in the United States is in the recovery of soda ash or sodium sulphate from the gases evolved in the furnaces of the black liquors of the pulp-making industries. Tests have been made in soda and sulphate mills, on different types of recovery furnace, and with recovery systems operating at different capacities. On an average, the loss, expressed as Na_2O, was about the same for soda and sulphate mills. The loss ranged from 20 to 85 lb. of Na_2O per ton of pulp produced, with an average of approximately 48 lb. of Na_2O per ton of pulp.

The mechanism of sodium sulphate reduction has been studied. The usual method of manufacturing sodium sulphide is by reduction of sodium sulphate with carbonaceous material at a temperature of 884° C. Commercial temperatures of reduction are said to be between 900-1,000° C.

Work at Michigan University

Work undertaken at Michigan University by White has been conducted to determine whether reduction could be effected at lower temperatures. The most active of solid reducing agents tested was bituminous coal. The reduction of sodium sulphate by hydrogen proceeds rapidly as long as the solid phase is present, but becomes slower when the formation of the liquid phase hinders diffusion of the gas into the mass.

Carbon monoxide is not as rapid a reducing agent as hydrogen. The addition of quicklime increases the rate of reaction with all solid reducing agents, at temperatures below 750° C., because of the removal of carbon dioxide as calcium carbonate. Complete reduction of sodium sulphate may be obtained in two hours at 700° C., and by bituminus coal and quicklime in one hour, at 750° C.

The features of the pressure process of Delavenna and Maillard,[9] for the manufacture of sodium chlorate, may be summarised as follows:—

1 Complete suppression of electrolytic reduction is effected (*a*) by removing continuously and rapidly the hydrogen, immediately it is formed, and (*b*) by continuously circulating the electrolytic liquor under pressure.

2 The process is carried out with a solution maintained permanently saturated by the addition of crystallised salt.

3 High-density electric current is used, and cooled brine is returned as a circulating medium.

4 By circulating under pressure, chlorine is carried along, and reacts, forming first hypochlorite, and then chlorate, without the release of chlorine.

Apparently, a large pressure is not employed, and by feeding from a height, sufficient head is created to obtain the necessary pressure to admit of the introduction of crystallised salt, without difficulty.

Possible improvements in methods of manufacture of sodium chlorate, with resultant lowering costs, are being studied by the U.S. Bureau of Chemistry and Soils. At the same time, the Bureau of Plant Industry is engaged on the experimental use of sodium chlorate in field trials on large areas.

The toxic action[10] of sodium chlorate persists for more than eight months, whereas that of potassium chlorate, which is initially comparable, disappears after three or four months. The difference in the sensitivity of various species of plant to chlorate injury has been established, cereals being amongst the most resistant. Thus, chlorate can be used to control weeds—for example, field buttercup—in green crops, without any sensible injury to the crop. The usually-employed dosage —1 lb. of chlorate to a gallon of water—is sprayed at the rate of 200 to 300 gallons to the acre, dependent upon the type of weeds encountered. To overcome fire hazard, an admixture with a deliquescent compound, such as two parts of calcium chloride, or one part of magnesium chloride, to two parts of sodium chlorate, renders the material safe, but slightly reduces the herbicidal power.

Methods of reducing fire risks in the use of sodium chlorate have been covered by Brit. Pat. 451,894 (1935).

Calcium Superphosphate

The author[11] has described in detail the present-day technique in the manufacture of calcium superphosphate, and has suggested a new standard to which all makes should conform.

A new process for the determination of the free acidity of superphosphate has been developed by Hans Lehrecke.[12] Cyclohexanol is said to be entirely without solvent action on monocalcium phosphate, in either aqueous solution or in phosphoric acid solution. Its solvent efficiency is limited to free phosphoric acid and sulphuric acid. The solvent can readily be recovered, and the efficiency of the extraction is not influenced by the grain size of the sample of superphosphate which is under test. This is a development of importance, and one that needs to be examined by chemists associated with the calcium superphosphate industry in this country.

The Maxwell den has excited interest, and a large Oberphos plant at Avonmouth has been brought to the production stage. There has been still further consolidation of the industry during the present year, and judging by recent reports, improved prices for fertilisers are to be anticipated shortly.

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(1) THE CHEMICAL AGE, June 6, 1936, 515.
(2) Brit. Pat. 441, 586 (1935).
(3) Dr. G. Roesener: Verein deutscher Chemiker, "Chem. Trade Journal," July 31, 1936, 83.
(4) "Chem. Trade J." March 30, 1936, 235.
(5) Brit. Pat. 452,528.
(6) "Chem. Trade J.," December 20, 1935, 530.
(7) THE CHEMICAL AGE, May 9, 1936, 423.
(8) Brit. Pat. 440,004 (1935).
(9) "Compt. rend." **202**, 1663, May 18th, 1936. (Electrochimie).
(10) R. C. Bickmore, "Fertiliser, Feeding Stuffs and Farm Supplies Journal," June 3, 1936.
(11) "Fertilisers, Feeding Stuffs and Farm Suppliers Jounal, July 1—15, 1936]
(12) "Chem. Trade J." August 1, 1936, 145."

Public Analysts and Other Analytical Chemists

By EDWARD HINKS, B.Sc., F.I.C.

THE public analysts of England and Wales examine during the year approximately 140,000 samples taken under the Food and Drugs (Adulteration) Act. The latest returns give the percentage of adulteration as 5.3 for the whole country, varying from nil in a small borough to 32.9 in an English county. What do these figures mean? Do they mean that of the food and drugs consumed by the people of this country 5.3 per cent. is adulterated? It is to be hoped not. Do they mean that the traders of Nottinghamshire are particularly wicked and that relatively great merit reposes in those of Tiverton? Not infrequently is it pointed out with satisfaction that the percentage of adulteration has, by the operation of the Act, been much reduced. Such may be the case, but have we only arrived at the point that it is a mere twenty to one chance that a purchase will not be adulterated?

The Selection of Samples

The truth is that so many circumstances influence the relative numbers of samples reported as genuine or adulterated that the percentages calculated from the data are not a correct representation of the extent to which adulteration prevails. In the first place the sampling is not purely random. Inspectors select their samples, *i.e.*, in addition to taking random samples just to establish a general control, they concentrate upon those articles or those vendors likely (in their experience) to disclose something that should not be: sometimes, like policemen, they are "acting upon information received." Such action is not taken in order to persecute anybody, but rather to fulfil the purpose of the Act with the best economy of time and money. Then in cases involving particularly difficult analyses the analyst may require more than one sample of the same article: he may have found the quantity of his sample insufficient and so call for another: each of these samples may be returned as adulterated and so disproportionately increase the number of the adulterated.

The alarming figure of 77.8 as the percentage of milks found to be adulterated in an English county is probably due to some extreme method of selection of the samples submitted to the public analyst. Further, the public analyst's statutory report recognises two categories ony—genuine and adulterated or not up to standard. There are many milks which from natural causes are not "up to standard": it would be unjust to call this adulteration. Sausages containing sulphite preservative, not declared, but in a proportion which would be permissible if declared; some fault in the labelling of condensed or dried milk, or an over-statement of the equivalent pints of the contents of the tin or package are offences against regulations—these figure in the returns, but it may well be admitted that they are hardly deserving of the ugly accusation of "adulteration."

Absence of Standards

On the other hand there are doubtless many samples which should, in the view of many, be reported against but which are classed as genuine because of the absence of statutorily or otherwise established definitions or standards. So, owing to these many circumstances, we cannot say what would be the figure representing the incidence of adulteration: it is to be hoped that it is not 5 per cent.

Tin in Demerara sugar has this year suddenly come into prominence. It may have been there all the time, but there is an unfortunate absence of data. Certainly the addition of a tin salt to the sugar during crystallisation has long been practised.

Mr. Edward Hinks, Public Analyst for the County of Surrey.

It has been stated that the use of stannous chloride began in 1881, its purpose being to preserve or improve the colour of the sugar. It is on record that in 1890 the quantity of tin varied from 0.25 to 0.33 grain per pound, and that in 1890 the West India Committee were advised, as the result of feeding experiments on dogs, that there was no danger to health in this proportion. This summer the Buckinghamshire County Council prosecuted a grocer for selling Demerara sugar containing 0.77 grain of tin per pound: in the opinion of the public analyst this proportion of tin was harmful and should not be allowed. It seems that there is sugar about which contains several times even this quantity of tin, but there are no court cases reported. The case was dismissed under the Probation of Offenders Act upon payment of costs.

What proportion, if any, is permissible? In 1907 there was a Local Government Board report on the question of tin in canned goods, and the conclusion arrived at was that a proportion of tin approximating to 2 grains per pound was evidence of potential danger to health. Since that date 2 grains per pound has, in general, been accepted as the maximum permissible proportion in canned goods, though the certainty of less is sometimes ensured by specification.

Canned goods and sugar, however, are not analogous. In the one the 2 grains is a concession to the unavoidable—articles kept in tins must of necessity be liable to contamination by tin, though if the matter were inquired into again it might be found that with improvement in manufacture, with lacquer and so forth, this limit might be lowered. In the other, sugar, the tin is an intentional and controllable addition, and if, as was stated in 1890, one-quarter to one-third of a grain was sufficient, then anything more is too generous an allowance now. Should any be permitted at all? The uncertainty emphasises the need for an authoritative ruling.

The Poisons Rules

Public analysts have been brought into contact with the Pharmacy and Poisons Acts more intimately than heretofore by the coming into force of the Poisons Rules in May of this year. Under the Acts it is the duty of the Pharmaceutical Society to ensure compliance with the provisions of the Acts by authorised sellers of poisons, *i.e.*, by pharmacists, who alone may sell Part I poisons. Under the Act of 1933, however, there is a new class of persons constituted, the listed sellers of poisons who may sell Part II poisons only. These listed sellers have to be registered with the local authority, and it is the duty of the local authority to ensure compliance with the provisions governing the sale of Part II poisons by persons other than pharmacists: this involves inspection of

the premises both of the listed sellers and of persons who, though not listed, may be selling Part II poisons.

The Analytical Methods Committee of the Society of Public Analysts and Other Analytical Chemists has convened a Poisons Sub-Committee, under the chairmanship of Dr. G. Roche Lynche, president, to investigate methods of assay for various substances appearing in the schedules of the Poisons Rules: in the first instance preparations of lobelia, gelsemium, aconite and ephedra are to be considered. These are Part 1 poisons and are not of direct and immediate concern to the local authority under the Rules, but methods of assay of preparations containing these alkaloids will be welcomed by all analysts, and public analysts amongst them, who are concerned with the analysis of medicines and drugs.

In addition to the above-mentioned Poisons Sub-Committee, other sub-committees have continued their work: from the Essential Oil Sub-Committee we have had Report No. 12 (the determination of ascaridole): the Reichert-Polenske-Kirschner process for butter has been reviewed and the work is continuing: the Milk Products Sub-Committee has issued its fourth, and final, report (Dried Milk): it is gratifying to note that the Fédération Internationale de Laiterie has, subject to approval by the permanent bureau and the national committees, adopted the methods recommended in this Report No. 4, following similar action on Reports Nos. 1, 2 and 3.

The methods of analysis of condensed and dried milk worked out by this sub-committee have the rosiest of prospects of being the agreed international methods. The third report of the Soap Sub-Committee will be published in January.

Not for one moment should it be thought that the work of these sub-committees is exclusively, or even mainly, that of public analysts. Not at all: the writer has previously been glad of the opportunity of acknowledging the debt of the public analysts to the "Other Analytical Chemists" with whom they are united in one society, for their co-operation in these and other matters: he would like to repeat the acknowledgment save that it might be more fitting, on numerical if on no other grounds, to phrase it rather as an appreciation by the public analysts of the privilege of being so associated.

This review opens with a reference to the samples received for analysis: it closes with one to co-operative efforts in devising methods of analysis. Analysis necessitates as much research as does any branch of chemistry. Individual investigational work also will be found recorded in the pages of the "Analyst."

Recent Developments in Solvents and Plasticisers

By ERIC H. BRITTAIN, B.Sc.

PERHAPS the more striking developments in connection with solvents this year have been in Russia in connection with the newly inaugurated synthetic rubber industry and in the United States, particularly at Mellon Institute. The Russian synthetic rubber industry has grown to large proportions as evinced by the fact that over 70,000,000 proof gallons of ethyl alcohol (*i.e.*, more than the entire British production) are required per annum as raw material. The first stage in the synthesis is the "cracking" of ethyl alcohol to butadiene, a reaction which also produces ethylene, butylene and other unsaturated compounds which can be converted by hydration, hydrogenation, etc., to a variety of solvents.

The Petroleum Cracking Industries

Great progress has also been reported in the petroleum cracking industries in both Russia and the United States, and although large amounts of the olefines produced during cracking are converted into gasoline by polymerisation, it seems definitely established that the manufacturers of solvents will, in the future, turn increasingly towards these substances as raw materials. It is evident from the published reports, that attempts are being made in Russia to build up such an industry along lines already exploited in England and the United States. Numerous papers have appeared dealing with the conversion of ethylene to ethyl alcohol, the oxidation of ethyl alcohol to acetaldehyde, the conversion of acetylene to acetaldehyde, the oxidation of acetaldehyde to acetic acid, the conversion of acetaldehyde to crotonaldehyde and the hydrogenation of the latter to butyl alcohol, etc. It is also stated that butyl alcohol can be obtained by hydrogenating the so-called "butyl fraction" (probably chiefly crotonaldehyde) obtained as a by-product during the butadiene synthesis.

Further work has been reported on the production of esters by two different processes; the first consists in passing vapours of the alcohol and acid to be combined over a catalyst, and the second by direct catalytic action on the alcohol itself. The former process has been used for the production of butyl acetate by passing acetic acid and butanol vapour at 150°-210° C. over active charcoal impregnated with phosphoric acid. In the direct process ethyl or butyl alcohols are passed over a catalyst consisting of copper containing a trace of cerium oxide at about 275° C., the alcohols being oxidised to aldehydes which are further condensed to esters. This process is, of course, limited to the production of ethyl acetate, propyl propionate and butyl butyrate.

These obviously great developments in Russia, however, seem to have had little influence on the general solvent position in Europe, though the time cannot be far distant when Russia will become one of the major producers of solvents and organic chemicals generally.

Mellon Institute Research

Interesting new fields are being opened up by the researches on basic solvents made under the direction of the Carbide and Carbon Chemicals Corporation at Mellon Institute. Ethylene diamine, propylene diamine and a number of their derivatives are now being made on a commercial scale in the United States. They have been found to be good solvents for casein, rosin and shellac, and on account of their strong basic nature are useful as acid gas absorbents. The cyclic ether amine, morpholine, is now available commercially and has been found to be a good dye solvent and general textile assistant. The ethyl and vinyl ethers of morpholine and morpholine ethanol have also outstanding solvent properties, and it has been said that there seem to be no other organic compounds with such a variety of solvent properties as the morpholines. In America as well as in Russia great changes are taking place in solvent manufacture as a result of the extended use of petroleum cracking olefines as raw materials.

Increasing quantities of ethyl, isopropyl, secondary butyl and secondary amyl alcohols are made from these sources, the isopropyl alcohol being chiefly converted into acetone, and the secondary butyl alcohol being converted mainly to methyl ethyl ketone. Normal butyl alcohol is also being made synthetically from acetylene, via acetaldehyde. The effect of synthetic products on the market which has, until recently, been supplied almost exclusively by fermentation products, has been very marked, and with the keener competition, prices have fallen considerably.

The production of methanol is still increasing, especially in European countries, particularly as it forms a source of motor fuel which could be made in any coal-producing country in times of emergency. The amount of methanol obtained from wood-distillation is gradually declining and amounts to less than 20 per cent. of the total. By a slight modification of

the methanol synthesis from water gas, higher alcohols can be obtained and a review of this process was given in the "Gas World," 1936, *104*, Coking Section, p. 38.

Ethyl alcohol production by fermentation is being pushed forward as rapidly as possible in Italy using home-produced sugar beet as raw material. It is intended to increase the annual production of ethyl alcohol by about 200 per cent. Distilleries are also being erected in Ireland using potatoes as the source of carbohydrate.

In the synthesis of alcohols from olefines, particularly ethyl alcohol from ethylene and isopropyl alcohol from propylene, some of the ethers are produced simultaneously and large quantities of isopropyl ether are being used in making high quality aviation fuels. A number of processes have been described for converting the ethers to alcohols and esters. In one process, for example, isopropyl ether is treated with acetic acid or acetic anhydride and sulphuric acid to give isopropyl acetate.

The use of isopropyl ether as a solvent is increasing, but a warning of the risks incurred when using old samples was published by Sir Gilbert Morgan and confirmed by other workers. This ether seems to form peroxides, under the influence of light and oxygen, even more rapidly than ethyl ether. These peroxides which remain as residues after evaporation of the ether are excessively unstable and dangerous. Methods for purifying peroxide-containing isopropyl ether have also been described.

The Higher Alcohols

The higher alcohols have attracted a great deal of attention recently, and a number of patents have appeared showing the synthesis of these alcohols from lower aldehydes and ketones by a series of reactions involving the aldol condensation and hydrogenation of the resulting unsaturated aldehyde or ketone. The hydrogenation can, if desired, be so arranged that the saturated aldehyde or ketone can be obtained. By this means a whole range of alcohols, aldehydes and ketones, both saturated and unsaturated, ranging in carbon content from four to twenty atoms in the molecule, have been obtained. The lower members of the series, *e.g.*, 2-ethyl butanol-1, 2-ethyl hexanol-1, have been claimed, together with their aliphatic esters as solvents, whilst their higher boiling esters, *e.g.*, the phthalates are said to be excellent plasticisers.

Although increasing numbers of substances are described each year as new solvents and plasticisers, the well-tried ester products, *e.g.*, ethyl acetate, butyl acetate, amyl acetate, diethyl phthalate, ethyl lactate, butyl lactate, etc., still continue to hold their own, and are responsible for the greater part of the business in this field. A few esters have been used commercially for the first time, particularly in the United States, for special purposes. Tributyl citrate has been found to be an excellent plasticiser for cellulose acetate films, while triamyl citrate has been found to be a suitable plasticiser in the production of matt acetate silk threads. Butyl propionate was also introduced as a high boiling lacquer solvent, but it is now reported that amyl propionate has since been widely accepted by industry in the United States in preference to the butyl ester over which it has the advantage of imparting better flow, greater brush resistance and a better odour to the lacquer. Butyl stearate has been used in the production of cosmetic preparations.

A number of patents still appear dealing with the manufacture of esters directly from olefines, *e.g.*, by absorption of the olefine in sulphuric acid and treatment of the resulting alkyl sulphuric acid, under various conditions, with an organic acid; although this has been repeatedly attempted, the difficulties of the process, attractive as it seems, do not yet seem to have been solved. In any case, the reaction proceeds very slowly with the lower olefines, whilst with the higher olefines polymerisation proceeds rapidly in the presence of sulphuric acid under conditions necessary for esterification.

The glycols and their derivatives have for a number of years occupied the attention of chemists, and with the rapidly increasing availability of new alcohols, acids, etc., increasing numbers of glycol esters, glycol ethers, glycol ether esters, etc., etc., are described "ad nauseam." The use of the lower monoalkyl ethers of glycol, known under the trade name "Cellosolves" still continues to be very considerable, both in the cellulose lacquer industry and in the textile trade for dyeing, printing and fibre lubrication. An interesting new use for "cellosolve" (ethylene glycol monoethyl ether) is impregnating wood to minimise the shrinkage and swelling brought about by moisture changes. The cellosolve can, in this connection, be used as a vehicle for impregnating the wood with oils, waxes, resins, etc.

A new method of making these glycol ethers was described, and consists in absorbing ethylene oxide (or other olefine oxides) in an alcohol, using an amine, *e.g.*, monoethanolamine as the condensation catalyst. The method is said to be particularly suitable for producing the higher glycol ethers. 1.3-decylene glycol and its esters have been reported as high boiling solvents and plasticisers for lacquers and varnishes. The dialkyl ethylene glycols, in which the alkyl group contains at least 12 carbon atoms, have also been described as plasticisers. Other typical plasticisers described for the first time are the glycol mixed esters, *e.g.*, ethylene glycol acetate succinate, and the ether-esters, Cellosolve salicylate, levulinate and acetyl-tartrate.

On account of the technical importance of the glycols, two independent investigations of their physiological properties have been made in the United States and Italy. It was shown in each case that exposure to glycol vapours is not harmful.

Chlorinated Solvents

Here, again, the well-tried solvents, carbon tetrachloride, chloroform, trichlorethylene and ethylene dichloride continue to hold their own. Considerable attention has, however, been directed to the chlorinated ether solvents. "Chlorex," the trade name for dichlor-diethyl ether, is well known and is used extensively as a solvent in the purification of lubricating oils. A new general method for making the dichlordialkyl ethers is by passing chlorine and an olefine into a solution containing a chlorhydrin. Thus by passing *propylene* and chlorine into *ethylene* chlorhydrin, β-chlorethyl β-chloriso-propyl ether is obtained. Dichlor di-isopropyl ether has also been obtained by dehydrating propylene chlorhydrin with sulphuric acid. It has a boiling point of 187° C. at atmospheric pressure.

Investigations on the monochlor alkyl ethers have been proceeding in Russia. Monochlor-ethyl ether can, for example, be obtained by the action of ethylene on ethyl hypochlorite; ethers of this type are said to be valuable solvents for resins, fats, waxes and cellulose derivatives. Yet a further ether recently described is β-chlorethyl β-chlorethoxy ethyl ether which is obtained by the interaction of ethylene oxide, chlorine and ethylene. It has a boiling point of 230° C. at atmospheric pressure.

Physiological investigations of the chlorinated hydrocarbons has shown that trichlorethylene is the most satisfactory solvent from this point of view; the other chlorinated hydrocarbons were shown to be decidedly toxic in character. Solvents containing fluorine in addition to chlorine have occupied some attention and carbon bisulphide has been found to be a suitable material for making these compounds.

Acetal (diethyl acetal) has for some time been used as a solvent, but a new example of this type of compound is ethylene formal obtained by the condensation of formaldehyde and ethylene glycol in the presence of hydrochloric acid. It has a boiling point of 73-75° C., and is said to be a good solvent for cellulose acetate.

An interesting paper appeared in "Industrial and Engineering Chemistry," 1936, *28*, 646, dealing with the evaporation of mixed lacquer solvents. It is shown that under average drying conditions of a lacquer the evaporation of a solvent mixture follows the simple process of distillation for azeotropic mixtures. A further paper, *Ibid. 28*, 1310, deals with the choice of solvent compositions for lacquers using mixed esters of cellulose, for instance, cellulose acetate propionate.

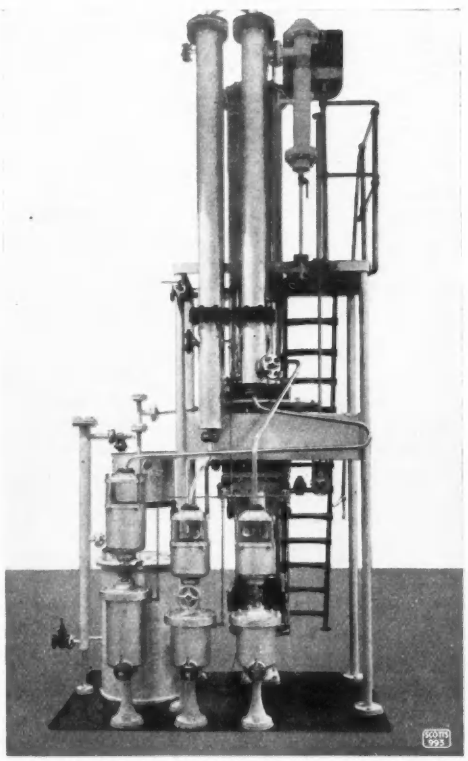
The Trend of Chemical Engineering in 1936

By H. A. S. GOTHARD, A.M.I.Chem.E.

Mr. H. Alec S. Gothard, A.M.I.Chem.E.

THE year now being reviewed will undoubtedly go down in the annals of chemical engineering history as one of more than passing moment. An event of far-reaching importance was the Chemical Engineering Congress of the World Power Conference, held in London in June. Most of the industrial countries of the world contributed to the proceedings. Coincident with this congress an exhibition of British chemical plant was held under the auspices of the British Chemical Plant Manufacturers' Association. The executive committee of the Association adopted the wise course of inviting non-members to participate, thus enhancing very considerably the scope and value of the exhibition, and it is to be hoped that appreciation of this generous gesture will be shown by a large increase in membership.

There are few industries which do not embody in some

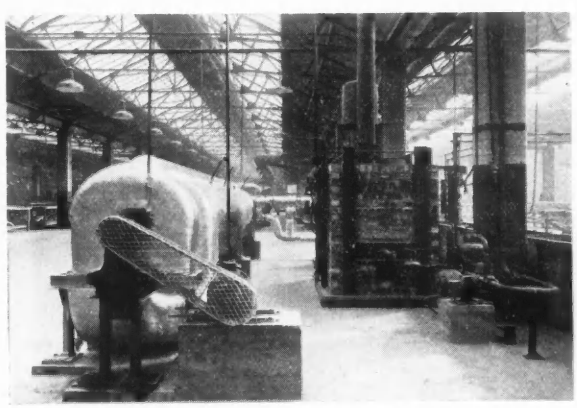


Patent high vacuum distillation plant (George Scott and Son (London), Ltd.)

phase of their operations chemical engineering principles. Wherever one turns, whether it is the manufacture of aircraft, coal-mining, dairy-farming, or the film industry, one finds the chemical engineer has applied his knowledge and experience of heat transmission, size reduction, corrosion, or vapour pressures to some specific problem. Thus it is possible to assume that those engaged in the design and fabrication of plant for the chemical and allied industries are benefiting by the general improvement in the trade of this country during the past twelve months. It is not merely assumption, however, because inquiries in all directions indicate increasing activity and in many instances expansion of works. The Government's rearmament policy has, of course, stimulated trade in certain branches of the chemical and engineering industries, but it is gratifying to note the more or less general adoption of a far-sighted policy of preparation for an industrial revolution rather than the anticipation of an international upheaval in the near future.

Whilst progress has continued in the design, employment of new materials of construction, and the methods of plant fabrication, it is in the adaptation of tried and proven principles to some complex chemical process, or their application to a previously uneconomic operation, that one really appreciates the trend of modern development in chemical engineering practice.

One example of this is to be found in the collection and recovery of waste products, and more especially in regard to the recovery of solvent and other organic vapours. The development during recent years of "adsorption" processes, employing activated carbon as the adsorbent, continues to be maintained and improvement in design is noticeable in many installations put into operation in the last twelve months. Lower operating costs and increased efficiency coupled with extensive research has brought the application of such processes very much to the fore, and the saving affected, together



Heat treatment oven. Kestner Patent Merilene System. (Kestner Evaporator and Engineering Co., Ltd.)

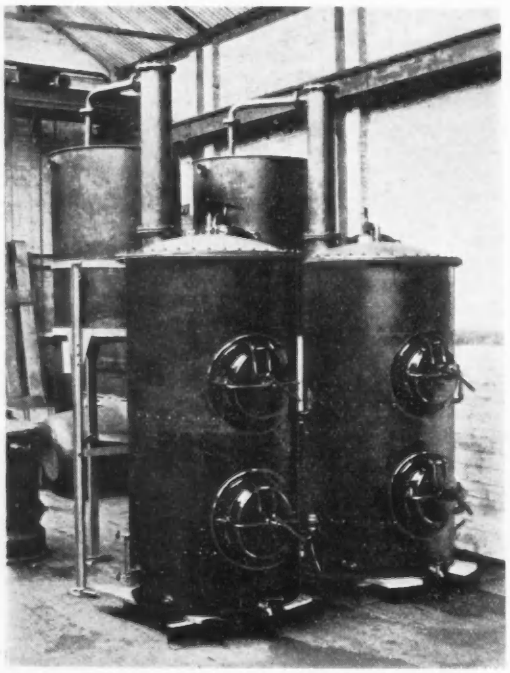
with improved working conditions, has enabled certain industries considerably to increase output without the expansion of production plant or the employment of additional hands.

The demand for new materials of construction is a problem with which the plant designer is constantly faced. The progress which has been made with phenol-formaldehyde resins

as a material for chemical plant fabrication is of unusual interest. Resins of the phenol-formaldehyde type have long been known to show a remarkable resistance to attack by hydrochloric acid, and it was the knowledge of these properties and the accepted unreliability of existing materials, earthenware and ebonite, possessing similar properties which led to the development of materials having this type of resin as their base. "Keebush," the registered trade name applied to a material of this type developed in this country, is being increasingly employed for pipework and fittings for hydrochloric acid: as it is also resistant to certain other acids, bases, salts, and solvents, wider applications have already been appreciated.

The success of glass-lined equipment has created a rapidly growing demand for plant of this type, particularly in the pharmaceutical and fine chemical industries, and in the processing of milk and food products. There is also an increasing demand for glass-lined storage tanks for dealing with edible oils, dyes, perfumes, vaccines and serums, fermentation liquors, and numerous other products. An important development which has taken place during the year has been the introduction in this country of glass-lined transport tanks for carrying sulphuric acid.

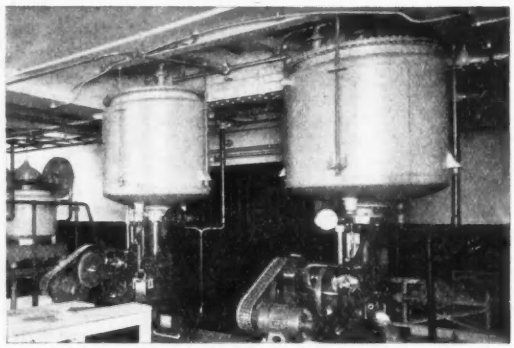
Unfortunately, it is not possible to attempt a summary of the numerous developments which the year now closing has witnessed. Among a few, however, to which reference should be made is the interpretation into practice of many years of research and experimental work on high vacuum distillation. A large-scale plant of this type has recently been put into operation for the production of chemically pure glycerine,



Copper Stills, 4 ft. diameter, for distilling essential oils. (W. J. Fraser and Co., Ltd.)

this being effected in one distillation from crude. Another is the completion of a large radiant heat dryer for the handling of pastes and slurries. The use of electricity for the direct heating of liquids, and also for heating purposes in connection with distillation and evaporation, has been strictly limited, and a still further development of notable importance is the application of this method of heating for chemical processes. Two systems have been introduced; in one, use is made of a metal strip coming into direct contact with the product to be heated, and the other provides for the direct heating of a metal tube or plate around, through, or over which the liquor to be heated is carried. The advantages of these systems will be obvious to those who have experienced the difficulty of preventing overheating of the product, and damage to the vessel by burning.

Bricks are normally of little interest to the chemical engineer, but a process both unique in itself and the product it turns out has recently been introduced to this country.



Pfaudler glass-lined equipment used in the preparation of ointment, toothpaste, etc. (Enamelled Metal Products Corporation, Ltd.)

Briefly, the process consists of mixing clay, sand, clinker, or any coarse material with chalk and a liquid chemical reagent. The admixture is then moulded in the usual form of brick press; the bricks so formed are placed in a vacuum tank for a short period after which the vacuum is released and CO_2 introduced. Within thirty minutes of leaving the press, it is claimed, the bricks are completely aged and ready for building into the wall. Apart from the saving in space utilised for aging, a saving in the cost of production of eight to nine shillings per thousand bricks is claimed. It will be appreciated that if these claims are substantiated the process may easily revolutionise the brick-making industry.

Rising Curve of Prosperity

The practice of prophecy is, at the best of times, dangerous, but there would appear to be little risk in suggesting that the trend of progress during the past year is likely to be maintained throughout 1937. Now that the country appears to be on a rising curve of industrial prosperity there is a definite indication that old industries will be modernised, and new ones fostered. Particularly is this to be expected in the distressed areas where plans are already being formulated for the introduction of industries specifically suited to local conditions. One of the most important suggestions so far offered in this connection is to be found in the recently published report on the Special Areas: "Another proposal which would use available raw materials, namely, limestone and coal, would be the installation of a factory in South Wales for the production of calcium carbide."

Calcium carbide is obtained by heating lime and carbon in an electric furnace. The application of heat causes the carbon in the coal or coke to combine with the calcium in the limestone thus forming CaC_2. The requirements, therefore, for production on a commercial basis, are a plentiful supply of easily quarried limestone, coal or coke, and cheap electricity. The raw materials are available in vast quantities in South Wales, and also in other districts, but the difficulty in the past has been the question of electric power. Most of the world supply of calcium carbide comes from countries which have adequate resources of water power for the generation of cheap electricity. In view of the many and important industrial uses of calcium carbide, and acetylene which is derived from it, the suggestion certainly warrants the closest investigation. A possible solution might be found in a "low temperature carbonisation—electro-generating" scheme!

The accompanying illustrations, which have been selected at random, show typical examples of the development of plant and equipment during the past year.

Colloid Chemistry in 1936

By H. FREUNDLICH

Professor H. Freundlich.

THE "Polaroid" films, transparent sheets producing polarised light, very large and not expensive Nicol prisms, so to say, are a remarkable application of colloid science. They were invented by E. H. Land[1] and are based in part on older experiments by Brewster, Zocher, Hatschek and others, who made thin polarising layers by orientating the crystals of dichroic substances (dyestuffs, etc.) on glass plates, for instance. Polaroid films are films of cellulose esters containing ultramicroscopic, non-spherical particles of strongly dichroic complex salts, for instance, herapatithe (a quinine iodine sulphate) which have been orientated by expelling the mass through a slit-like die, thus making use of the phenomenon, known as stream dichroism. Such films may prove to be valuable in manifold cases: for removing the glare of reflected light, so troublesome in photography and when motoring, for producing stereoscopic effects, etc.

Stream Double Refraction

Stream double refraction which has been thoroughly investigated in sols of oxides, dyestuffs, etc., has now been found in various solutions of proteins,[2] besides those of myosin, and serves for determining the shape of the colloidal particles.

A very powerful ultracentrifuge of the type designed by Svedberg (rotating up to 70,000 r.p.m.) has been installed at the Lister Institute for Preventive Medicine, London.[3] Other forms of such machines have been introduced by McBain,[4] Schlesinger,[5] and others. McBain uses an air driven spinning top; Schlesinger lets a thin layer of liquid rotate in a hollow cylinder on a Sharples ultra centrifuge and maintains a concentration gradient in the sedimentation equilibrium by keeping a part of the centrifuged substance in the state of a very dilute gel. The great number of possibilities opened by these ultracentrifuges have been increased by the fact that viruses and bacteriophages appear to consist of particles having a well defined ultramicroscopic size and shape.

It is one of the most important results of Svedberg's work with the ultracentrifuge that the proteins have characteristic molecular weights which are multiples of a certain unit. Perhaps one is right in giving them distinct patterns as is done by Miss Wrinch[6] who assumes the aminoacids in the proteins to be arranged in very large rings; the formulæ of hæmin, of chlorophyll, of the phthalocyanins have already made us acquainted with similar ring structures.

The Faraday Society Discussion

A general discussion of the Faraday Society[7] deals with a second type of organic colloids, as they are formed by the polymerisation of small molecules; the macromolecules of these polymerised substances generally show a broad continuous range of molecular weights (cellulose, rubber, resins, polymerised aldehydes, styrenes, etc.). The kinetics of their formation does not yet lend itself to any simple formulation. The viscosity of these substances in solution is known to be an important property, but one which is not easy to deal with (anomalous viscosity, yield values, etc.). As the treatment of these questions from a theoretical point of view is very complicated, it seemed more hopeful to attack these problems experimentally by investigating the viscosity of suspensions whose particles are large, but well defined as to size and shape.[8] Suspensions of small glass spheres and rods, of spores of a mushroom (the puff-ball), and of fine silk threads were used for this purpose.

The investigation of aqueous solutions of colloidal electrolytes with a long-chain cation have led G. S. Hartley[9] to a conception of the constitution of these solutions which somewhat differs from the one generally accepted. He also assumes micellar ions consisting of large aggregates of the long-chain ions, but believes that they are formed already in low concentrations, thus causing the drop in equivalent conductivity. The rise of the latter at higher concentrations then does not appear to be due to the greater mobility of these micelles, but to the fact that the small ions of opposite sign are bound in a smaller amount or less strongly to the aggregates of long-chain ions.

Solutions of one or more hydrophilic colloids may be frequently induced under suitable conditions to form a second liquid phase which has a very different concentration of dispersed substance than the other one. This phenomenon is not readily treated from the standpoint of the phase rule. It has been termed coacervation and has been studied thoroughly by Kruyt and Bungenberg de Jong. The latter has published two monographs on coacervation and its importance in biology[10] which will be welcome to all who wish to have first hand and concise information about this interesting chapter of colloid chemistry.

A Standard Method

To determine the electrophoretic behaviour of microscopic particles when varying the *p*H and other conditions, as initiated by Jaques Loeb, Abramson and others, is becoming more and more a standard method of analysing, so to say, the surface of these particles. In this way one was able to confirm[11] that the particles of Hevea latex are coated mainly with a layer of proteins which, at higher concentrations of the latex, is thick enough to make the particles behave as protein particles. In a similar way the distribution of proteins and lipoids on the surface of the starch particles of wheat flour was investigated.[12] An electric current acting upon

(1) E. H. Land, Brit. Pat. 412,179; 1932. Cf. Essay by Pollard ("Nature," 1936, **138**, 311).
(2) G. Boehm, "Biochem. Z." 1936, **284**, 322; Wöhlisch and Belonoschkin, *ibid.* **284**, 353. As to the stream double refraction of solutions of other organic colloids cf. Signer, "Trans. Faraday Soc." 1936, **32**, 296; A. M. Taylor, *ibid.* **32**, 307.
(3) "Lancet" 1936, p.874.
(4) McBain and O'Sullivan, "J. Amer. Chem. Soc." 1935, **57**, 780; McBain and Stuewer, "Kolloid Z.," 1936, **74**, 10.
(5) Schlesinger, "Nature," 1936, **138**, 549.
(6) Wrinch, *ibid.*, 1936, **137**, 411; **138**, 241; "Protoplasma," 1936, **25**, 550.
(7) "Trans. Faraday Soc.," 1936, **32**, 3.
(8) Guth, "Kolloid Z.," 1936, **74**, 147; Krasny-Ergen, *ibid.* **74**, 172; Guth and Simha, *ibid.* **74**, 266; Eirich, Bunzl and Margaretha, *ibid.* **74**, 276; Guth, *ibid.* **75**, 15; Eirich, Margaretha and Bunzl, *ibid.* **75**, 20.
(9) G. S. Hartley, B. Collie and C. S. Samis, "Trans. Faraday Soc.," 1936, **32**, 795; G. S. Hartley, Aqueous Solutions of Paraffin-Chain Salts. A Study in Micelle Formation. Actualités scientifiques et industrielles, Paris, 1936.
(10) Bungenberg de Jong, La Coacervation, les Coacervates et leur Importance en Biologie. Actualités scientifiques et industrielles. Paris. 1936.
(11) Kemp and Twiss, "Trans. Faraday Soc.," 1936, **32**, 890.
(12) Kemp, *ibid.* **32**, 837.

aqueous colloidal solutions of graphitic acid drives the particles to the anode, owing to electrophoresis. But under suitable conditions (*e.g.*, high viscosity of the sol) with sufficiently high voltages (about 200 volts) the particles close to the cathode may be reduced to graphite before they have time to move away. Thus dendrites of graphite can be formed.[13]

Starch from which all phosphoric acid, originally present in form of esters, has been removed can not be distinguished from normal starch as to its colour, when reacting with iodine.[14]

The capacity of electrolytes to coagulate hydrophobic sols has been shown to be equal, if the activity coefficient of the ions of opposite charge in the solution has the same value.[15] Since according to the theory of Debye and Hückel the activity coefficient depends on the ionic strength of the solution, the influence of ions of the same sign as the particles is also taken into account.

Concentrated Solutions

Concentrated solutions of acids (sulphuric, phosphoric acid, etc.) and of other electrolytes (*e.g.*, $CaCl_2$) are so different from dilute solutions of these substances that colloidal particles are not coagulated, but are kept in stable suspension; sols of sulphides, oxides, etc., were prepared in this way.[16]

One has succeeded in elucidating the action of ultrasonic waves upon colloidal and somewhat coarser systems.[17] Weak ultrasonics may firstly orientate the particles of suspensions provided that they are plate- or rod-shaped. Secondly, they may coagulate coarser particles of any shape by accumulating them in the nodes or antinodes (Kundt's dust figures in liquids). Ultrasonics of higher energy may thirdly have disruptive and destructive effects, emulsifying liquids in each other, liquefying thixotropic gels, etc. This kind of action is in most cases due to the collapse of cavitations in the liquid. These cavitations can be made directly visible.

The rate of thixotropic solidification of gels and concentrated suspensions may be increased by a suitable gentle movement, a phenomenon which has been called rheopexy.[18] It is probably due to a mechanical coagulation of the particles. This is confirmed by the observation that ultrasonics, under the same conditions where they are able to coagulate dilute suspensions, accelerate strongly the solidification of concentrated rheopectic suspensions, for instance of gypsum in water.[19] Thixotropic sludges are being used more and more as drilling fluids when boring for petroleum.[20]

Bound Water in Gels

An experiment strongly in favour of the existence of bound water in gels has been done by Hatschek.[21] He showed that gelatin gels containing cobaltous chloride turn from pink to blue on drying, when the water content of the gel is still about 30 per cent.; this is about the water content where, according to Moran, there is no formation of ice in the gel at any temperature. The swelling of collagen fibres in aqueous solutions of electrolytes[22] and the swelling pressure of isinglass in the same liquids[23] also appear to confirm the importance of bound water in these processes and the necessity of distinguishing the taking up of water due to this affinity from an exchange due to a Donnan effect.

Volume changes occurring when a gel is formed from a sol may differ strongly;[24] there is no change in a thixotropic gel of iron hydroxide; a decrease in gels of methyl cellulose, an increase in those of gelatin, a 10 to 20 times greater increase in those of silicic acid. The latter fact suggests a chemical process of dehydration going on during the formation of the gel.

Cases are known where organic colloids can not be distinguished as to their chemical constitution, though they differ markedly in their swelling capacity: the one kind swelling to an unlimited extent and finally dissolving completely, the other swelling only to a certain limit. Staudinger[25] has shown that this may be caused by the following mechanism: pure styrene, for instance, is polymerised under all conditions to products soluble in organic liquids; but if a small amount of p-divinylbenzene is added to the styrene before polymerisation, the product formed is not to be distinguished from those mentioned, but for the fact that it swells only to a limited extent. The foreign molecules appear to unite the macromolecules of polystyrene to a gel of limited swelling capacity by forming bridges between them.

The amount of dissolved substance adsorbed in equilibrium on the surface of aqueous solutions towards air has been determined by separating the surface layer from the bulk of the liquid by a suitable microtome.[26] Both the positive adsorption in solutions of phenol and hydrocinnamic acid, and the negative adsorption of sodium chloride agree quantitatively with the values calculated from Gibbs' adsorption equation.

The very strong influence of small changes of pH on the surface tension of soap solutions, investigated especially by Powney, is a surprising effect. It may be explained[27] by a displacement of the hydrolytic equilibrium in the surface layer and by the fact that the free fatty acid or the acid soap is much more capillary active than the neutral soap. From the values of the surface tension, which may be attributed to the neutral soap, the amounts adsorbed can be calculated from Gibbs' equation; the adsorbed film is found to behave as a gaseous one.

Bowden[28] has described a method for determining the temperature on the surface of metals sliding on each other. Even if a thin layer of lubricant is between them, the temperature may rise to about 600° C.; hence, the layer of lubricant may readily be interrupted and destroyed.

Aerosols, *i.e.*, fogs and smokes, are becoming more and more a matter of interest. How our knowledge of this subject stands to-day may be learnt from a general discussion of the Faraday Society.[29] The rate of coagulation of smokes,[30] to which Smoluchowski's theory of coagulation may be applied successfully, and the coagulation of aerosols by heat[31] and by ultrasonics[32] deserve to be specially mentioned. The action of ultrasonics appears to be mainly due to a so-called orthokinetic coagulation, *i.e.*, a coagulation caused by the fact that particules of different size, moving with different velocities, are driven together.

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(13) Luke, Madgin and Riley, "Nature," 1936, **138,** 161; H Thiele, *ibid.* **138,** 688.
(14) M. Samec, E. Waldschmidt-Leitz and K. Mayer, "Z. physiol. Chem.," 1936, **242,** 165.
(15) Wo. Ostwald, "Kolloid Ztschr," 1935, **73,** 301; 1936 **75,** 39, 297.
(16) Voet, Dissertation, Amsterdam, 1935, and "Kolloid Ztschr," 1936, **76,** 114. Cf. also Wo. Ostwald and Wannow, "Kolloid Z.," 1936, **76,** 159.
(17) Bondy and Söllner, "Trans. Faraday Soc.," 1935, **31,** 835, 843; 1936, **32,** 556; Söllner and Bondy, *ibid.* **32,** 616; Freundlich and Söllner, *ibid.* **32,** 966; Söllner, *ibid.* **32,** 1537; F. J. Burger and K. Söllner, *ibid.* **32,** 1598.
(18) H. Freundlich and F. Juliusburger, *ibid.*, 1935, **31,** 920; F. Juliusburger and A. Pirquet, *ibid.*, 1936, **32,** 445.
(19) F. J. Burger and K. Söllner, *loc. cit.* 17.
(20) P. Evans, "Sands, Clay Minerals," 1936, **2,** 9.
(21) Hatschek, "Trans. Faraday Soc.," 1936, **32,** 787.
(22) Jordan Lloyd and Marriott, *ibid.* **32,** 932.
(23) H. Freundlich and P. S. Gordon, *ibid.* **32,** 1415.
(24) Heymann, *ibid.*, **32,** 462. Heymann, The Sol-Gel Transformation. Actualités scientifiques et industrielles. Paris, 1936.
(25) Staudinger, Heuer and Husemann, "Trans. Faraday Soc.," 1936, **32,** 323.
(26) J. W. McBain and R. C. Swain, "Proc. Roy. Soc.," A., 1936, **154,** 608.
(27) N. K. Adam, "Trans. Faraday Soc.," 1936, **32,** 653.
(28) Bowden and Ridler, "Proc. Roy. Soc.," A, 1936, **154,** 640.
(29) "Trans. Faraday Soc.," 1936, **32,** 1042.
(30) Whitlay-Gray, *ibid.* **32,** 1042; Whitlaw-Gray, Cawood and Patterson, *ibid.* **32,** 1055; Cawood and Whitlaw-Gray, *ibid.* **32,** 1059.
(31) H. H. Watson, *ibid.* **32,** 1073.
(32) Brandt and Hiedemann, *ibid.* **32,** 1101; "Kolloid Z.," 1936, **75,** 129; Brandt, *ibid.* **76,** 272; Brandt, Freund and Hiedemann, *ibid.* **77,** 103; Andrade, "Trans. Faraday Soc.," 1936, **32,** 1111; R. C. Parker, *ibid.* **32,** 1115. Fogs may also be produced by ultrasonics; this is again mainly an effect of cavitation on the surface of the liquid which is being dispersed (Söllner, "Trans. Faraday Soc.," 1936, **32,** 1532).

Progress in Textile Bleaching, Dyeing and Finishing

By A. J. HALL, B.Sc., F.I.C., F.T.I.

Mr. A. J. Hall

FOR several years past the British textile industry has struggled hard to capture a dominant share of the home market and to build up a large export trade such as it had before the great war. As yet, it has been successful mainly in the home market; orders for export are exceptionally difficult to obtain. Yet at the present time our textile industry is definitely improving, especially in the rayon and wool sections; the Lancashire cotton section still lags and whilst the Midland hosiery trade is good it is probably not quite so brisk as it was one or two years ago.

All this intense effort to secure trade has been accompanied by a considerable amount of research into the scientific and technical problems which naturally arise in so complex an industry as that connected with textiles, and it is interesting to review here some of the main lines of progress.

Bleaching and Related Processes

Some old-time dyers used to avoid cleaning textile materials before dyeing with a view to preventing the consequent loss of weight, but in these days it is commonly accepted that all fibres should be purified to a high degree, since it is only by taking this precaution that coloured materials having the desired handle and fastness properties can be produced. The past year has produced many new and useful facts about textile bleaching.

The general rule still hold good that chlorine is the cheapest and most widely used beaching agent for cotton and cellulosic fibres, whilst hydrogen peroxide is the main product used for bleaching wool and real silk, athough it must not be forgotten that these protein fibres are often whitened by exposure to the fumes (sulphur dioxide) from burning sulphur. Quite a large amount of work has been directed towards improving the hydrogen peroxide bleaching process. For example, sodium metaphosphate together with acetanilide or phenacetin or salicylic acid has been found excellent for adding to the hydrogen peroxide solution itself or the bleaching liquor for increasing its stability (Brit. Pat. 435,401), and by means of such stabilised bleach liquor it is possible (Brit. Pat. 434,599) to produce a good white on cotton goods with a very low consumption of oxidising power. By drying into wool dilute hydrogen peroxide solution acidified with oxalic acid (Brit. Pat. 451,026) or boric or phosphoric acid (Brit. Pat. 451,115) it is claimed that a good white which does not after-yellow is obtained. This latter process is novel in so far as wool is always bleached in an alkaline hydrogen peroxide liquor.

Scouring Processes

In scouring processes it has been found that the detergent value of ordinary soap can be considerably increased by the addition of various phosphates (Brit. Pat. 435,710, 435,475, 435,465, and 435,562). Scouring liquors containing peroxides or other forms of active oxygen and which are used near to the boil cannot be stabilised by the products ordinarily employed, but magnesium silicate (Brit. Pat. 435,861) and aluminium hydroxide (Brit. Pat. 436,235) are then recommended as stabilisers.

Arising from investigations of a viscosity method for determining the degree of damage in real silk, S. R. Trotman ("J. Soc. Chem. Ind.," 1936, *55*, 325T) has shown that the addition of a small amount of soda ash to the usual soap degumming liquor can cause quite a large amount of deterioration in silk. It is also interesting to note that an appreciable amount of damage was caused to silk degummed by means of an enzyme preparation (papain) although it would be expected that this agent would be harmless. Mercerisation is one of the most important preparatory treatments of cotton for dyeing and finishing. As yet, no satisfactory substitute for caustic soda has been discovered, but now that mixture materials, containing both cotton and viscose staple fibre, are being increasingly used and, because when they contain a large amount of cotton they can be improved by mercerisation, it is likely that caustic potash may be used instead of caustic soda, since the former alkali has a very much less harmful action on the rayon. This phase of textile treatment has been carefully investigated by O. Mecheels ("Textilber," 1936, *17*, 725) and H. Korte, E. Kayser and W. Waibel ("Textilber," 1936, *17*, 864).

Many new wetting-out agents for addition to mercerising liquors have been discovered, and they allow this treatment to be carried out on the non-desized cotton material. Among such agents are to be found a mixture of butanol and tetrahydrofurfuryl alcohol (Brit. Pat. 444,605), a mixture of cymene-parasulphonamide, fencholic acid and a phenol (Brit. Pat. 439,436) and mono-chloroxylenol (Brit Pat. 441,070). The use of barium hydroxide for determining the degree of mercerisation of cotton materials has been described by Edelstein (Amer. Dyestuff Rep., 1936, *25*, 186).

Dyeing and Printing

During the past year progress has been made not only in the application of the well-known classes of dyes to the various fibres but in devising methods so that classes of dyes usually applied to one type of fibre can be applied to other fibres for which they normally have no practical affinity. Especially has it been found possible to treat cellulosic fibres so that they can be dyed with acid wool dyes. This particular line of progress has come as the result of increased use of various quaternary ammonium and similar high valency phosphonium and sulphonium compounds which usually contain aliphatic chains of not less than about C_8 and also pyridine and quinoline residues. For example, viscose rayon impregnated (Brit. Pat. 440,647) with methyl-dibutyl-dodecyl-ammonium bromide or stearyl pyridinium chloride (that is, compounds having the general formula: $R_1R_2R_3R_4N.OH$) can be dyed with acid dyes such as are commonly used for wool. A certain amount of nitrogen can be fixed in cotton so that it has acid dyeing properties by treating it (Brit Pat. 441,448) with epichlorhydrin in the presence of ammonia. The addition of albumin (10 per cent. on the weight of cellulose) to a viscose spinning solution results in rayon (Brit. Pat. 440,449) which can be dyed with acid dyes.

The finishing of cotton materials with synthetic resins so as to make them uncreasable has led to the discovery (Brit. Pat. 433,210, 433,143 and 450,516) that the presence in cotton

or viscose rayon of a urea- or thiourea-formaldehyde resin gives it an affinity for acid dyes. Direct dyes on cellulosic fibres can be improved as regard their fastness to washing by impregnation with a synthetic resin (Brit. Pat. 435,868 and 437,642). Betaine products such as may be produced by reacting chloro-acetic acid with pyridine (Brit. Pat. 420,095) or by condensing certain halogenated aliphatic sulphonic acids with tertiary amines (Brit. Pat. 446,269) have proved very useful in vat dye printing pastes in so far as they promote better fixation of the dye.

The addition to the dye bath of certain quaternary phosphonium compounds (Brit. Pat. 435,443) for example, triethylcetylphosphonium bromide or ternary sulphonium compounds (Brit. Pat. 435,444) for example, methylethyldodecyl-sulphonium hydroxide, assists level dyeing when vat dyes are employed. Also the pre-treatment of cotton with similar products (Brit. Pat. 443,588) for example, triphenyldichlorobenzyl phosphonium chloride, gives it an increased affinity for dyes of the Soledon and Indigosol type. Cotton is more easily dyed with indigo after treatment with high valency nitrogen, phosphorous, and sulphur compounds (Brit. Pat. 448,272).

Dyeing of Cellulose Acetate Rayon

In connection with the dyeing of cellulose acetate rayon it should be noted that during the past year a new range of water-soluble dyyes (Solacet, I.C.I.) have been introduced. These are of the azo type and their composition is described in Brit. Pat. 441,884 and 441,089. At the present time difficulty is often experienced in dyeing very deep shades to avoid the defect of rubbing when the hitherto used suspension type of dye is employed; these new water-soluble dyes should help to remove this difficulty.

Another useful discovery relating to acetate rayon is that the rapid fading in sunlight of the matt type of wet dyed rayon (the titanium dioxide present in the rayon accelerates fading) can be prevented (Brit. Pat. 449,543) by an after- or pre-chromium treatment; matt viscose rayon can be similarly improved (Brit. Pat. 448,262). The use of an oxalate in dyeing logwood on matt acetate rayon has been protected (Brit. Pat. 440,594), and this is important, for it is frequently overlooked that an excellent fast black shade can be produced on this type of rayon with logwood. Semi-carbazides such as phenylthiosemicarbazide have been found useful for after-treating dyed acetate rayon so that its colour is not affected by gas fumes (Brit. Pat. 450,475).

Considerable new information has recently been obtained concerning the mechanism by which textile fibres absorb and retain dyes. J. B. Speakman ("J. Soc. Dyers and Co.," 1936, *52*, 121) has published results of a careful investigation of the dyeing of wool with acid dyes and established that the amount of dye absorbed from a circulating dyebath is a linear function of $\sqrt{t}$ (t=time) in spite of the falling concentration of dye present. Finer fibres dye more quickly than coarse fibres. Elod ("Textilber," 1936, *17*, 67) has shown the definite manner in which the *p*H of the dyebath can influence the dyeing of wool with acid dyes, and R. Haller ("Helv. Chim. Acta," 1936, *19*, 15) has stressed the part played by the swelling of the wool fibre.

S. M. Neale ("J. Soc. Dyers and Co.," 1936, *52*, 252) has summarised the past few years' progress in understanding the manner in which direct dyes are absorbed by cotton and cellulose rayons. Apparatus for measuring the diffusion rates of direct and acid dyes is described by E. Valko ("Trans. Faraday Society," 1935, *31*, 230).

Finishing Processes

Apart from the discovery of a large number of agents suitable for softening and delustring various types of textile fabric, considerable interest has centred around methods for making fabrics resistant to shrinkage and creasing. Recently a new interest has been taken in the waterproofing of fabrics and garments and the American "Neva-Wet" process is now being introduced into England.

In spite of the availability of ready dulled (matt) rayons quite a large amount of fabrics, both woven and knitted, has to be dulled by the finisher. For this purpose use is made of fine dispersions of titanium dioxide and other opaque pigments, and recently the tendency has been to produce these in such a form that they are substantively absorbed by silk and rayon fibres; the previous padding methods are therefore somewhat less important. A good description of the use of titanium pigments for this dulling is to be found in the "Hosiery Times," 1936, *10*, No. 88, 25.

Synthetic resins (usually urea-formaldehyde) are still favoured for treating cotton, rayon, and now linen (Brit Pat. 437,361) so as to produce resistance to creasing, but quite recently it has been claimed (Brit. Pat. 455,472) that the formaldehyde treatment of a cellulose material itself is sufficient to give this same resistance to creasing. A new anti-crease process has been described in Brit. Pat. 439,294, and the various anti-crease treatments now available are described in a useful article by H. Rein ("Textilber," Eng. Edit., 1936, *17*, 112). W. Weltzien (Ibid., 114) has described methods for measuring crease resistance.

Use of Synthetic Resins

Finishing methods for making fabric unshrinkable largely depend on mechanical devices, but more recently the use of synthetic resins has proved of assistance. Some problems of cloth shrinkage have been discussed by N. Cryer ("J. Text. Inst.," 1935, *26*, 331 P). Synthetic resins of the urea-formaldehyde type have also proved useful (Brit. Pat. 435,240) for fastening inorganic fire-proofing agents in textile materials. A mixture of potassium carbonate and sodium bicarbonate is claimed (Brit. Pat. 433,645) to be a good fireproofing agent. Brit. Pat. 432,389 describes a process for printing figured effects on cotton and rayon fabrics by means of solutions of cellulose, and in this connection it is to be noted that certain metal perchlorates can dissolve (A. Dobry; "Bull. Soc. Chim," 1936, *3*, 312) cellulose. Quaternary benzylammonium hydroxide is also a good solvent (Brit. Pat. 439,806) for cellulose.

For new knowledge concerning the properties of wool such as enter into its finishing processes reference should be made to the valuable researches of J. B. Speakman (J. Soc. Dyers and Col.," 1936, *52*, 335, 380, and 423; "Textilber," 1936, *17*, 582, 659 and 736). In the near future it is likely that dyers and finishers will have to make the acquaintance of artificial (casein) wool, which is known in Italy as Lanital, and of which particulars have been given by P. A. Koch ("Z. ges. Text. Ind.," 1936, *39*, 306; H. C. Borghetty, "Text. Res.," 1936, *6*, 465; "Text. Res.," 1936, *6*, 188).

Newcastle Chemical Industry Club

Scientific and Social Activities

In the course of the past twelve months Mr. R. H. F. Houstoun has been elected chairman, following the resignation of Mr. H. Dunford Smith, and the secretarial duties have been passed from Mr. F. H. Walker to Mr. E. B. Davies. The club's scientific and social activities have been most varied. In the winter months a number of talks have been given by members on subjects largely of topical interest, while once per week French and German circles have met for the study of technical works in these languages.

The library of scientific literature, under the direction of Mr. P. D. Scott, the hon. librarian, still proves a valuable asset to the club. Many new books have been added during the year, including the latest publications on chemical engineering and applied chemistry, which are found to be in great demand.

On the social side contract bridge and billiards continue to attract a considerable following, while in the summer months outdoor activities included the organisation of excursions to numerous local places of interest, and the annual golf competition for the Trobridge Cup, which was won this year by Mr. G. H. Whitfield.

Fatty Oils and Soaps in 1936

By PROFESSOR T. P. HILDITCH, D.Sc., F.I.C.

Professor T. P. Hilditch, Professor of Industrial Chemistry, Liverpool University.

IT is easy, among the many reports of progress which, as usual, indicate activity in this branch of applied chemistry, to discern especial interest in adapting well-known fatty oils to new uses, in increasing the available supplies of fatty oils, and in devising substitutes for some which, owing to abnormal economic conditions or for other local reasons, are difficult to obtain in necessary quantities.

For years the technical grades of olive oil have held their position in certain textile industries in consequence of their capacity of not developing undue heat by oxidation when exposed to air in thin films on the textile fibre. Recent events in Italy and Spain have had a serious effect on imports of olive oil to this country, and intensive efforts are now being made, with the co-operation of the Wool Industries Research Association, to find a substitute. It is said that the resultant saving to the wool industry might be as much as £120,000 per annum, and that already a product has been marketed which fulfils the requisite conditions. To some of those who appreciate the requirements of the trade it has been somewhat puzzling that olive oil, relatively expensive even under normal conditions, should so long have been accepted almost as an essential. The problem of devising a good substitute from some of the cheaper vegetable fatty oils ought to be capable of complete solution, and there would appear to be more than one method of approach reasonably likely to lead to success.

Cultivation of the Soya Bean

The cultivation of the soya bean is a subject of perennial interest, probably because it can serve as raw material for a variety of other products in addition to its fatty oil. The soya bean crop in the United States in 1935 was nearly twice as large as in 1934, and an industrial research laboratory has been installed in Illinois to follow up comprehensively the study of the cultivation of the bean and of the uses to which its fatty oil and other products can be put. Soya beans have been grown in England to yield seed containing 16 per cent. of oil and 38 per cent. of protein, and it has been stated that the bean might be cultivated profitably in the south of England in warm summers; the last proviso seems to suggest that the business might prove a somewhat speculative one.

Articles have recently been published in "Industrial and Engineering Chemistry" in which the uses of the oil in the edible fat and soap industries have again been discussed at some length, and in which it is also pointed out that, although soya bean oil is a poor drying oil, the film of the oxidised (dried) oil possesses good permanent elasticity and freedom from colour. It is suggested that the drying power might be improved by hybridisation and cultural conditions. Research in this direction may in process of time effect the desired result, but it may be asked whether the same end could not better be reached by employing mixtures of soya bean oil with other more powerfully drying oils.

Substitutes for Linseed Oil

Substitutes for linseed oil are of special importance in Germany, where the use of this oil in paints is at present restricted by Government decree. In that country the trend is more towards the use of alternative products than of alternative fatty oils. Oils obtained by the Scheiber process from castor oil, whereby the ricinoleic glycerides are converted into conjugated octadecadienoic or "linoleic" glycerides, are coming into technical favour. This material naturally resembles tung oil rather than linseed oil in its drying and polymerising properties, owing to the conjugated unsaturated system present. It is said that during 1936 there will have been used in Germany some 40,000 tons of another product, "EL-varnish," which contains only 30 per cent. of linseed oil in admixture with other materials, the most important of which (probably phthalic anhydride resins) are derived from naphthalene. Other proposed substitutes for linseed oil are polymerised polyene hydrocarbons derived from cracked gases or from synthetic gasoline produced from water gas by the Fischer-Tropsch process, and oils obtained by condensing naphthenes with some of the acids obtained in the oxidation of petroleum hydrocarbons.

The production of tung oil by cultivation in different parts of the world in sub-tropical regions is developing steadily, especially in the southern United States, but not so rapidly that the trade is content to abandon the search for other oils with similar properties. So far the only promising rival is oiticica oil, which contains keto-elaeostearic as well as (or instead of) elaeostearic glycerides.

There seems to be general agreement that oiticica oil is inferior to tung oil, chiefly because the dried films have a lower resistance to moisture than tung oil films, and also on account of a greater tendency to gelatinise during storage; on the other hand, the oiticica oil film is said to be more resistant to penetration or attack by carbon dioxide and other gaseous products of combustion. The lower resistance to moisture may be connected with the presence of the ketonic group, and this constitutive feature may also be the reason that oiticica oil condenses very readily with cresols to yield useful phenolic resins. The practical point has been made recently, however, that wild and not plantation trees must be relied upon as the source of the oil, since the oiticica tree requires nearly a hundred years to reach maturity.

Whale and Fish Oils

It is realised that at least some of the inability of whale and fish oils to serve as satisfactory substitutes for linseed oil in paints is due to the comparatively large proportions of saturated and monoethylenic acids which accompany the highly-unsaturated C_{20} and C_{22} acids in combination as mixed glycerides in the oils. Various methods are being attempted to remedy this defect from the paint oil standpoint. The more unsaturated glycerides can be concentrated to some extent by freezing the oil and separating the solidified portion, which contains more of the saturated and monoethenoid glycerides than the remaining liquid; the drying or heat polymerising properties of the latter are thereby improved to some extent. A more thorough separation is obtained by hydrolysing the oil in the first place and then slowly distilling the mixed fatty acids by a special process. The highly-unsaturated acids are polymerised in the still and subsequently used as "whale oil stand oils," while the saturated and monoethenoid acids distil over and are subsequently condensed and used for soap.

Reference should be made here to a group of patents by Imperial Chemical Industries, Ltd., in which the use of

" molecular evaporation " at high vacuum (0.001-0.0001 mm.) and a high temperature is proposed in order to effect the separation of fatty oils into various products. So far as the writer is aware these processes are not yet in technical operation, but the proposals involve essentially novel methods of handling fatty materials. One process, for example, is to pass fish oils through a " molecular still " at 250-260°; the highly unsaturated glycerides polymerise during the treatment to products of the " stand oil " type, while glycerides which do not contain a highly unsaturated acyl group evaporate at the temperature and pressure employed, and are thus separated as a condensate.

Refining of Crude Fats

The same principle is also to be applied to other ends. For example, crude fats may be directly refined, after removal of mucilaginous matter, by passage through a similar still; free fatty acids and other impurities, such as rancidity products, evaporate at 200-220°, and the glycerides themselves at 250-260°, leaving only a residue of resinous and unsaponifiable matter. It is claimed that in suitable instances it is possible to obtain colourless, odourless, neutral glycerides in yield equal to 90 per cent. of the weight of the crude fat employed. Again, similar treatment of butter fat is stated to yield at 180-250° 10-30 per cent. of a condensate which contains all the flavouring and vitamin compounds present in the original fat, while vitamin-rich, tasteless concentrates are produced in like manner by treatment in the " molecular still " of fish-liver oils which have been partly hydrogenated under carefully controlled conditions.

Much experimental study is still directed towards a more complete understanding of the complex changes which take place during the heat polymerisation of oils, and Waterman's investigations in this field have included the use of the short-path high vacuum evaporation as a means for separating polymerised from non-polymerised glycerides. When the polymerisation of simple (methyl or ethyl) esters of unsaturated fatty acids is studied, as in the researches of Steger and van Loon, Kino and others, ordinary fractional distillation at 0.1-0.2 mm. pressure serves to separate the unpolymerised esters from the polymers.

Polymerisation of Linseed Oil

It seems almost certain now that heat polymerisation of linseed oil (or other derivatives of linoleic or linolenic acid) is preceded by rearrangement of some of the unsaturated groupings $-CH:CH.CH_2.CH:CH-$ into the conjugated form $CH:CH.CH:CH.CH_2-$. Steger and van Loon, studying heat polymerised ethyl linoleate, found, in addition to the polymerised ester and unchanged ester, about 5 per cent. of a conjugated octadecadienoic ester and about 10 per cent. of a cyclic monomeride. Taylor and Smull have observed, in the air oxidation of linseed oil, that the product commenced to react with maleic anhydride (the Diels-Alder reaction for conjugated unsaturation) at the point when its iodine value and refractive index were undergoing rapid change. Both these observations support the theory of Scheiber that preliminary rearrangement as above to a conjugated system precedes polymerisation in the linseed oil molecule. The Diels-Alder reaction with maleic anhydride has been utilised as a quantitative determination for tung oil (or rather for conjugated unsaturation in fatty oils); it may be significant that linseed oil shows a small apparent content (ca. 5 per cent.) of conjugated unsaturated groups when the maleic anhydride test is applied to it. On the other hand the polyethenoid acids of cod liver oil form no crystalline adduct with maleic anhydride, so that conjugated unsaturation is presumed to be absent.

In the field of fat hydrogenation much interest is at present shown in the use of nickel catalysts which are active at low temperatures (*e.g.*, 70-100° C.). " Raney nickel " catalyst (*i.e.*, nickel prepared by treatment of a nickel-aluminium or nickel-silicon alloy with aqueous caustic soda) is active at low temperatures and is said to favour selective hydrogenation. It has been claimed that use of a nickel catalyst active at or below 70° enables linseed oil to be converted into a non-drying oil which is free from polyethenoid unsaturation and which remains liquid (but viscous) at 0°. It is also stated that hydrogenation of cod liver oil below 100° can be effected without loss of more than a small proportion of the vitamin potency of the oil (the catalyst in this case was obtained by decomposition of nickel carbonyl in a separate portion of the oil at 120-145°).

Nickel Formate as Catalyst Source

On the Continent especially, the use of nickel formate as catalyst source for ordinary fat hardening at 170-180° seems to be making headway as compared with the older nickel-kieselguhr catalysts; it is claimed that nickel produced from formate shows greater resistance to fluctuations of temperature and to catalyst poisons present in the fats treated. It is interesting to read a report from the United States which shows that the use of electrolytic hydrogen in large-scale fat hydrogenation is increasing there rapidly; within the last five years sixteen electrolytic hydrogen plants, with a total daily output of over 2,000,000 cubic feet of hydrogen, have been put into operation.

There is not a great deal to be said this year about soap manufacture. The most interesting features are, perhaps, the descriptions of the high pressure high temperature saponification process which have appeared. In this process the fat charge is mixed intimately with the requisite amount of caustic soda or sodium carbonate in concentrated solution and passed at 50-100 atmospheres pressure through a narrow, short reaction tube held at 300° C. The time of passage is about 30 seconds, during which saponification is completed and the extruded product is cooled and spray-dried, so that the fat is converted into powdered dry soap completely in a single operation, and at high speed. An infommative review of the fatty materials used at present in this country and in America in the soap trade has recently been given by W. H. Simmons; it is remarkable, in view of the wide range of fats available and quoted as soap-making materials, to find that tallow, coconut oil, palm oil and hardened whale or fish oils account together for about 95 per cent. of the whole of the fats converted into soap in the United States in 1933.

In Germany much attention is being devoted to replacing fats by other soap-making materials and, in addition to acids produced by the catalytic oxidation of petroleum, " tallöel " from the sulphate-cellulose process (a mixture of rosin and fatty acids) is being adopted with some success as a substitute.

Investigation of Detergents

The development and technical investigation of the newer types of sulphated or other synthetic detergents continues steadily, with concurrent publication of many reports in the literature. A new form of detergent, stable to hard and to acid water and unique in containing no salt-forming group, has been patented by Lever Brothers, Ltd.; this consists of mono-fatty acid esters of one or more polyglycerols. Solubility in water results from the accumulation of aliphatic hydroxyl groups in the condensed glycerol molecules, and the long-chain acyl ester confers the lathering power and other physical properties which make the material a good detergent.

Much work has also been published in other branches of the subject, for example, the perennial topic of rancidity and atmospheric oxidation of fats. A sufficient number of fats from all kinds of living organisms has now been examined to bring out beyond doubt the broad, but very striking, relationships between component fatty acids and biological relationships based upon the evolutionary theory; this parallelism was the subject of an article in " Nature " during the year. A review of the year's activities in fats and soaps would be incomplete without a reference to the useful and valuable work steadily carried on by committees of the Society of Public Analysts and of the American Oil Chemists' Society, by the International Commission for Fat Analysis and by other bodies in connection with the improvement and standardisation of methods of rapid analytical control of raw fatty materials and their products.

The Nitrogen Industry in 1936

By E. B. MAXTED, D.Sc., Ph.D., F.I.C.

Dr. E. B. Maxted, Department of Chemistry, Bristol University.

THERE has been little radical change in the general position of the nitrogen industry during the present year; and the industry may now—in contrast to the conditions which obtained in it during the period of relatively rapid development of nitrogen fixation—be regarded as having attained a stabilised state in which the methods of production have become standardised and the potential output more than enough to satisfy the existing demands, at any rate under normal conditions. In the summary contained in the previous annual report, mention was made, in connection with European exports, of the construction of new nitrogenous fertiliser plants in the Far East; and this movement is apparently continuing[1]. Further, among proposals for the manufacture of nitrogenous products in other countries, the proposed production of alkali cyanides in South Africa[2] may be noted.

Synthesis of Ammonia

Two publications dealing with the preparation and use of natural iron ore catalysts may be noticed. V. P. Kamzolkin and V. L. Livschitz[3] have described the preparation of ammonia catalysts from Ural magnetite by a process which includes fusion with a small quantity of potassium nitrate and alumina. A further naturally occurring ore, siderite, is stated by J. A. Feldman, K. N. Ivanov and A. I. Naumova[4] to yield as active a catalyst as magnetite and, with this ore, no advantage was obtained by purification or by adding bodies such as magnesium carbonate. It will be observed that the first of the above two preparations involves the use of two promoters, potash and alumina, commonly used with other types of iron catalyst.

The preparation of the gas mixture required for the synthesis has also received further attention. Thus, G. Fauser[5] has described the production of a hydrogen-nitrogen mixture by the interaction of carbon with a mixture of steam and air under pressure and at a temperature between 650° and 800° C. The air should be present in sufficient quantity to convert the greater part of the carbon monoxide into dioxide. In a process which has been discussed by N. I. Kobozeff, J. S. Kazanovski, and L. I. Kaschtanov[6], the mixture required is obtained from a raw material produced by exploding methane with oxygen-enriched air. Other papers dealing with various aspects of the synthesis include one by N. P. Kapustin[7], who considers the spent circuit gases as a source of argon and other inert gases, and an investigation by V. Finkelstein, M. Rubanik and H. V. Poljakova[8] of the kinetics of the synthesis. The transport of ammonia, from synthetic and other plants, by using a solution of ammonium nitrate or certain other nitrates, in which gaseous ammonia is readily soluble, has been discussed by K. A. Zeidenberg and M. A. Iljinskaja[9].

Ammonium Salts

The concentration of ammonia liquor does not fall necessarily within the scope of ammonia synthesis, but two patents dealing with this subject may, in view of the relatively small volume of literature on the matter which has appeared during the year, conveniently be included in the present section. J. L. Bennett[10] has claimed a process of the type involving the passage of steam under pressure up a packed tower which is fed from the top with aqueous ammonia. A concentrated solution is obtained at the top of the tower, and a weak solution from the bottom. A further process employing steam in countercurrent to ammonia solution in a concentration tower is due to D. Pyzel[11].

The preparation of coarsely crystalline ammonium sulphate has been discussed in two patents granted to the Interessen-Gemeinschaft[12]. According to one proposal, slightly acid solution of ammonium sulphate is mixed, prior to evaporation, with a small percentage of sodium sulphate. Another salt suitable for admixture with neutral sulphate solutions is magnesium sulphate. Small quantities of these foreign bodies are stated to lead to the production of larger crystals. A further body of this type is aluminium sulphate[13], which induces the formation of non-caking hexagonal scales of ammonium sulphate.

The formation of neutral ammonium sulphate from coke oven gas by a process involving the absorption of part of the ammonia in water and the conversion of this to sulphate by the action of sulphur dioxide and air, in the presence of a salt of cobalt or manganese as a catalyst, has been proposed by F. Denig.[14] The acidic solution produced is neutralised by the remaining ammonia from the gas. In another process[15] ammonia, sulphur dioxide and air are caused to react in the presence of oxides of nitrogen, and R. K. Fulton[16] has claimed a method of manufacture in which ammonium sulphite is oxidised with air or oxygen under pressure. For developments in plant for sulphate manufacture, reference may be made to U.S. Pats 1,997,757 and 2,000,038. Finally, for the manufacture of ammonium sulphite or bisulphite R. W. Richardson[17] has claimed a process in which sulphur dioxide is passed upwards in countercurrent to a falling shower of water, the ammonia being introduced into the tower at different levels.

The formation of ammonium nitrate in the vapour phase has been dealt with by H. A. Beekhuis[18] and by V. A. Klevke.[19] The yield of nitrate is stated to be quantitative if a slightly over 50 per cent. excess of nitrogen peroxide is present. In connection with other ammonium salts attention

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[1] THE CHEMICAL AGE, 1936, **34**, 84, 356; **35**, 299.
[2] THE CHEMICAL AGE, 1936, **34**, 355.
[3] "J. Chem. Ind. Russ.," 1936, **13**, 398; ex Brit. Chem. Abs., B, 1936, 639.
[4] "J. Chem. Ind. Russ.," 1935, **12**, 1036.
[5] Brit. Pat. 442,594.
[6] "J. Chem. Ind. Russ.," 1935, **12**, 1030.
[7] Ibid., 1936, **13**, 464.
[8] "Acta Physicochim. U.R.S.S.," 1935, **3**, 945.
[9] "J. Chem. Ind. Russ.," 1935, **12**, 683.
[10] U.S. Pat. 2,012,621.
[11] U.S. Pat. 1,999,546.
[12] Brit. Pat. 435,007 and 440,807.
[13] Brit. Pat. 445,120.
[14] U.S. Pat. 1,973,892.
[15] U.S. Pat. 1,989,124.
[16] U.S. Pat. 1,986,889; see also J. W. Sperr, U.S. Pat. 1,980, 99.
[17] U.S. Pat. 2,004,799.
[18] U.S. Pat. 2,011,704.
[19] "J. Chem. Ind. Russ.," 1936, **13**, 164.

may be called to a proposal by M. Shoeld[20] in which superphosphate is used for the recovery of ammonia from town gas, and to a method which uses a closed gas circuit for the production of ammonium chloride from ammonia and hydrochloric acid in the gas phase.[21]

Nitric Acid and Nitrates

A number of modifications in platinum gauze catalysts for use in the oxidation of ammonia have been proposed. Thus, G. M. Hickey[22] claims the use of platinum alloys containing small percentages of rhodium and cobalt, and L. Handforth[23] has claimed platinum alloyed with rhodium and tungsten. The use of platinum-rhodium-tungsten alloys has also been discussed by I. E. Adadurov and V. I. Atroschtschenko.[24] A suitable alloy of this type has a high activity and exhibits little corrosion even after prolonged use. Platinum containing 3 per cent. of tungsten alone is stated to be more active and more resistant to corrosion than alloys containing rhodium. Several proposals have been made for a gauze of alloy, or even of base metal, covered, in each case, with platinum. Thus, J. N. Tilley and H. Whitehead[25] recommend a platinum alloy containing rhodium, silver, copper or nickel, coated with pure platinum. A. E. Adadurov and A. N. Prozorovski[26] find that platinising nickel gauze does not prevent corrosion.

Turning to base metal catalysts, E. D. Crittenden[27] has suggested the purification of cobalt for use, in the form of oxide, as an ammonia oxidation catalyst, by melting it with calcium fluoride and calcium carbonate. A. O. Jaeger[28] claims a process of ammonia oxidation in which the ammonia-air mixture is freed from organic impurities by passage over a pre-catalyst containing oxides of iron and vanadium.

A number of patents deal with the absorption of nitrogen oxides. N. Caro, A. R. Frank, R. Wendlandt and T. Fischer[29] have described a process of fractionation of the reaction product from ammonia oxidation plants by progressive cooling. F. W. de Jahn[30] has emphasised the beneficial effect of immediate impingement on cooling tubes. The adsorption of oxides of nitrogen by silica gel has been studied by M. J. Schapiro and A. M. Savinaev.[31] The silica gel employed had a water content of over 10 per cent., and regeneration was effected by passing air at 150-200° C. The product was principally nitric acid. Improvements in the enrichment method for the production of concentrated nitric acid are discussed by the Hydro Nitro Soc. Anon. and T. Hobler.[32] The process is of the type in which gases from ammonia oxidation are passed up a packed tower which is fed with dilute nitric acid.

Other Nitrogen Compounds

The preparation of nitrates from halides has also received attention. Thus, L. Rosenstein[33] passes nitrogen peroxide over fused potassium chloride, when potassium nitrate is formed. A mixture of potassium chloride with the nitrate melts at a considerably lower temperature than the chloride itself and may be used in place of this.

V. F. Postnikov, T. I. Kunin and N. A. Eremeeva[34] have investigated the production of calcium cyanamide by the interaction of calcium oxide or carbonate with gases containing ammonia, nitrogen and carbon monoxide. The cost per unit of fixed nitrogen is stated to be considerably less than if the calcium syanamide is made by the action of nitrogen on calcium carbide. The same authors have also re-discussed the use of a small percentage of calcium fluoride in the preparation of calcium cyanamide from calcium carbide and nitrogen.[35] H. N. Gilbert[36] has claimed a process for the manufacture of sodium cyanide by heating calcium cyanamide with carbon and sodium. The resulting product is treated with water and with aqueous sodium carbonate, when sodium cyanide is formed and calcium carbonate precipitated.

The production of urea from ammonia and carbon dioxide has been studied by H. W. de Ropp and H. C. Hetherington.[37] The gases are heated to slightly over 200° under pressure and the urea separated by cooling and centrifuging. For details, reference should be made to the original specification. Finally, a process for the conversion of urea into ammonium cyanide has been described by G. Siegle and Co. and W. Koenig.[38] A mixture of urea with ammonium sulphocyanide and with a finely divided metal such as iron is heated, when ammonium cyanide sublimes and a metallic sulphide is left in a form from which the metal can be recovered for further use.

[20] U.S. Pat. 1,980,006.
[21] U.S. Pat. 1,987,572.
[22] U.S. Pat. 2,018,760.
[23] U.S. Pat. 1,978,198.
[24] " J. Appl. Chem. Russ.," 1936, **9**, 1221; " Ukrain, Chem. J.," 1936, **11**, 209.
[25] U.S. Pat. 2,004,101.
[26] " J. Appl. Chem. Russ.," 1935, **8**, 1321.
[27] U.S. Pat. 2,017,683.
[28] U.S. Pat. 2,010,235.
[29] U.S. Pat. 1,989,267.
[30] U.S. Pat. 2,016,810.
[31] " Sborn. Trud. Ukrain. Chim. Inst. Odessa," 1935, p.106; ex Brit. Chem. Abs. B., 1936, 318.
[32] Brit. Pat. 447,952.
[33] U.S. Pat. 2,007,478.
[34] " J. Chem. Ind. Russ.," 1935, **12**, 795.
[35] " J. Appl. Chem. Russ.," 1936, **9**, 1021.
[36] U.S. Pat. 2,015,668; E. I. Du Pont de Nemours & Co. and H. N. Gilbert, Brit. Pat. 437,614 and 437,615.
[37] U.S. Pat. 2,017,588.
[38] Brit. Pat. 438,402.

Society of Glass Technology

Recognition of Special Services

ALTHOUGH the Society of Glass Technology has held seven ordinary general meetings during the year these were overshadowed in interest and importance by functions arranged in connection with the International Congress on Glass which met in London and Sheffield from July 2 to 11. The two bodies on which the responsibility for the congress mainly rested were the Society of Glass Technology and the International Commission on Glass, the Society being the inviting body. The president of the Society, Mr. Bernard P. Dudding, filled the office of president of the congress. Professor W. E. S. Turner, hon. secretary of the Society and president of the International Commission on Glass, was general organising secretary of the congress, which was officially opened in London by the Duke of Kent.

It was particularly appropriate that the International Congress on Glass should have been held in England in 1936, as that year marked the twenty-first anniversary of the founding of the Department of Glass Technology of the University of Sheffield, the pioneer of its kind. In 1936, the Society of Glass Technology, which developed out of the work of the Department of Glass Technology, reached its twentieth year of service.

At its annual general meeting the Society made an important change in its constitution and rules, in that a new grade of membership was instituted—that of Fellow. Fellows are deemed to be persons who, as members of at least five years' standing, have rendered special service in promoting the objects of the Society.

Hitherto published quarterly, the " Journal of the Society of Glass Technology " was issued bi-monthly in 1936. It contained some 70 original papers and reports as well as 1,200 abstracts of other papers. The large increase in the number of papers was due to the inclusion of most of the papers communicated to the International Congress on Glass. A full report of the Congress proceedings appeared in the August issue of the " Journal." The three local sections maintained their activities during the year, as did also the Society's special committees dealing with glass standards, furnaces, refractory materials, form, design and process work. The most notable loss in membership during the year was that of Professor H. le Chatelier, of Paris, who was an honorary member of the Society.

The Voice of the Industry

Extracts from Representative New Year Messages

Alcock (Peroxide) Ltd.

A MORE general recognition of the unique and valuable detergent properties possessed by the new industrial alkali, sodium metasilicate, a product in which Alcock (Peroxide), Ltd., has specialised for several years, became evident during 1936. Independent investigators, as a result of observations both in the laboratory and factory, have come to recognise its general superiority for many and varied cleaning problems, with the result that the demand for the product is continually increasing. The plant for its manufacture has been enlarged during the year, and is capable of meeting any increased consumption which may accrue. During the year the production of sodium sesquisilicate and other crystalline silicates has been further developed.

It is interesting to note that the activities of this company in the direction of sodium metasilicate followed their investigations of peroxide of hydrogen processes. During 1936 the company again turned its attention to the manufacture of peroxide of hydrogen and per-salts, and a large plant for their manufacture is rapidly approaching completion. The most modern electrolytic process will be employed, by which a product of consistent stability and purity will be produced. It is anticipated that deliveries will commence early in the new year.

Bausch and Lomb Optical Co., Ltd.

THE past year has been outstanding in the history of the London offices of the Bausch and Lomb Optical Co., Ltd., which were moved from Hatton Garden to Africa House, Kingsway, in June. In these new offices the company has every opportunity of advantageously demonstrating the wide range of laboratory and industrial instruments manufactured by them, and the move has enabled them to increase the range of standard instruments which can be held in stock. A healthy feature of their trade in 1936 has been the large increase of sales to industrial concerns of all types. They are looking forward during 1937 to still further increasing their showroom facilities. Their factory has plans in hand for the introduction of several new and modified instruments for the coming year. Outstanding amongst these will be a range of low power binocular microscopes having improved mechanical features.

Boots Pure Drug Co., Ltd.

DURING 1936 Boots Pure Drug Co., Ltd., continued to extend their manufacturing units at their Beeston factory. A section of the fine chemical department came into operation and further developments in this section are in progress. Work on the construction of their new factory for the manufacture of "dry" products is making steady progress. A section of the factory is equipped with the most modern plant for the grinding, sifting, mixing and packeting of powders both for medicinal and toilet use and is now working at full pressure.

The demand for Boots' fine chemicals and special medical products has increased considerably during the year and their special facilities for manufacturing drugs and chemicals place the company in a unique position for assisting medical research by making available for clinical trial new products shortly after their discovery. Important recent additions to their special medical products are Neoket, a pleasantly flavoured, effervescent, granular preparation containing mandelic acid, and Ammoket, an elixir of ammonium mandelate suitably flavoured. Neoket and Ammoket have proved to be of great value in the treatment of urinary infections. Other new products of interest are Rheumelim, a preparation containing compound, effervescent piperazine granules for the treatment of rheumatism, gout, sciatica and all arthritic conditions, and Matrilac, a combination of milk sugar with vitamin D and the essential supplements for preparing humanised milk.

At the beginning of the year Boots Pure Drug Co., Ltd., acquired the business and goodwill of Electro-Chemical Processes, Ltd., and have now taken over the manufacture of the horticultural sprays known as Bouisol (colloidal copper compound), Sulsol (colloidal sulphur) and Flosol (colloidal bairum silicofluoride) for the prevention of fungus diseases in gardens, glasshouses, orchards, farms, etc.

An interesting development in the firm's overseas activities is the opening of new branches in New Zealand. The five-day week plan is now permanently established in their Nottingham factories and arrangements have been made for the retail staff to have shorter hours, a scheme which is working most satisfactorily. Of the future it may be said that Boots Pure Drug Co. enjoy the growing confidence of the public and the medical profession, and there is every reason to hope that the demand for their services and numerous products will create another record in 1937.

Bowmans (Warrington), Ltd.

AS far as 1936 is concerned, Bowmans (Warrington), Ltd., have not made any further additions to their plants for sulphonated oils and lactic acid. They are, however, finding a much bigger demand for their pure sulphonated olive and their Turkey red oil; both these products are being used for cosmetic purposes. During the year they have also started the production of a new liquid soapless tonic shampoo and a haircream.

The British Drug Houses, Ltd.

DURING 1936 the British Drug Houses, Ltd., have marketed a number of new products of considerable interest in scientific circles. There can be but few laboratory workers who are not familiar with the catalogue of B.D.H. laboratory chemicals which now includes well over 5,000 items. The most recent discoveries in medical science demand the utilisation of modern chemical and engineering technique for bringing the results of research to practical realisation. The members of the B.D.H. scientific staff are constantly engaged on work of this character, and new medical products are marketed when the need for them has been clinically demonstrated.

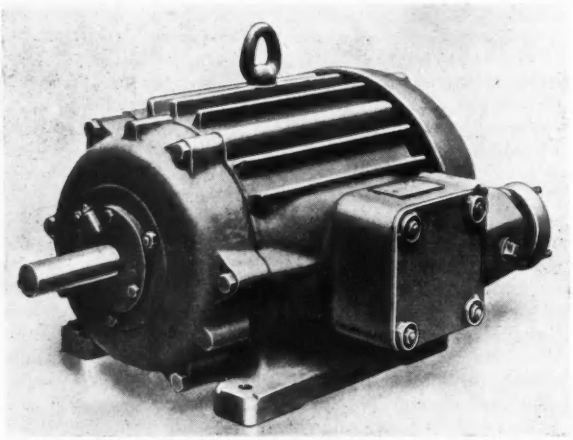
The recent introduction of Anahaemin, the highly active haematopoietic principle of liver described by Dakin and West, has been a great event in the treatment of pernicious anaemia. There has been intense interest and enthusiasm in this discovery and the B.D.H. has had the distinction of being the first to issue this important product. The introduction of mandelic therapy is another outstanding therapeutic advance in combating diseases of the urinary system, and has received an enthusiastic reception by the medical profession. In addition to being large-scale manufacturers of pure mandelic acid the B.D.H. has issued special outfits which embody the use of either sodium mandelate or ammonium mandelate for attack upon a very common and disabling condition. Medical science has made rapid strides during the past twelve months, and the B.D.H. has shown great ability and determination to keep well abreast of every new system of medication.

British Thomson-Houston Co., Ltd.

INTENSIVE research work has been carried out by the British Thomson-Houston Co., Ltd., during the year, and many developments have taken place. The improvement effected in synthetic resins for varnishes and moulding powders has resulted in extending applications of B.T.-H. synthetic resinous products. Work on varnish resins has been mainly directed towards enhanced electrical characteristics and

towards obtaining products of low water resistance, improved adhesiveness and mechanical strength.

All kinds of electrical equipments, suitable for the chemical industry, have been produced in the company's factories, including turbo-alternators for generating electric power and supplying process steam, transformers, switchgear, motor generators, rotary converters, rectifiers, power factor improvement plant and Mazda lamps. In addition, various types of motors and control gear have been manufactured, the former including machines of the flameproof class suitable for installations where there are dangerous explosive gases; totally-enclosed fan-cooled motors for use in situations where there is excessive dust and other foreign matter, and geared motor units for low speed drives.



One of the line of new squirrel-cage motors of the British Thomson-Houston Co., Ltd., designed, built and tested for flameproof industrial service in chemical works, etc. The motor shown is a typical 10 h.p. 1,500 r.p.m., totally-enclosed fan-cooled machine.

Thomas Broadbent and Sons, Ltd.

THE ever-increasing demand for standard type and special type centrifugals has kept Thomas Broadbent and Sons, Ltd., working full pressure during the past year. They have made extensions to their premises, and installed a considerable number of the very latest type machine tools to expedite production. Many special type centrifugals of exclusive design, for specific and secret processes, have been made by them, and developments have taken place in machines with variable speeds and some running at extremely high speeds, including a centrifugal with a 26 in. diameter imperforate basket to spill over the lip, running at 3,500 r.p.m., and driven by vertical motor with tex-rope drive.

Another entirely new type to be introduced is an inclined-spindle ploughing centrifugal, with motor drive. This machine is for treating large quantities of crystalline products with a minimum amount of labour, and offers many advantages over the usual standard type machine. The material is fed into the revolving drum, centrifuged, and discharged by means of a hand-operated plough and chute. Great developments have taken place during the year in the use of various brands of stainless steels and special alloys for the construction of baskets and linings.

Butterworth Bros., Ltd.

THE year 1936 has been one of marked progress for this firm. They have erected and put into operation a new oil-fired tank furnace, specially designed for the accurate founding at high temperatures of heat resisting and similar types of glass. They are one of the oldest contractors to the Government for their requirements in glass. The company has been specially invited by the Department of Overseas Trade to send certain glasses to be shown at the International Exhibition, Paris, 1937. The glasses in question, which will be shown in the British Pavilion, are two-gallon and four-gallon pear-shaped carboys, and a four-gallon swan-necked carboy. These are of the type which are traditional in druggists' shops.

Coley Thermometers, Ltd.

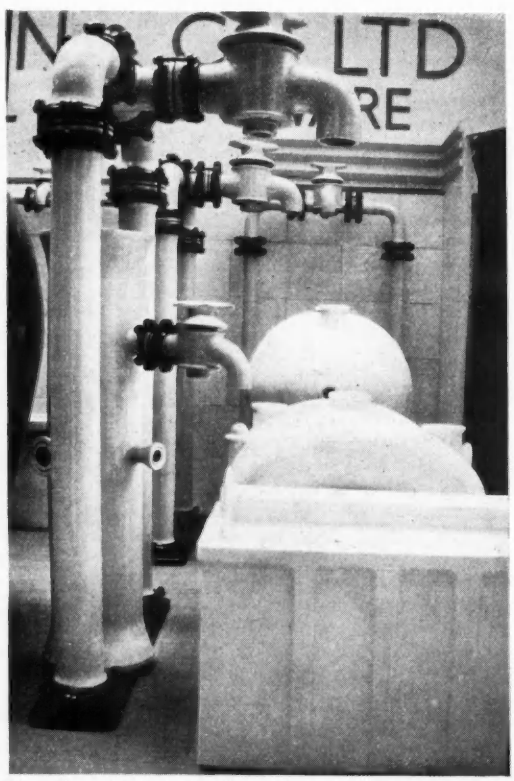
THE business of this company has so increased during the last eighteen months that they have had to build new and larger premises and are moving into them in the New Year. Here they will employ a bigger staff and have new machinery installed and be able to manufacture new ranges of thermometers.

W. S. Dahl

A LONDON industrial chemist, with whom W. S. Dahl is collaborating, has succeeded in grinding ordinary waste paper and old newsprint to a fine mesh powder, with the aid of a patent machine he has invented. The powders are made in three grades—fine, medium and coarse, and should have many uses as fillers. The same chemist has also succeeded, at very small cost, after many other chemists have failed, in producing a very white wood flour containing no deleterious acids or alkalies which should be welcomed by moulding manufacturers to enable them to give a translucent effect to their synthetic resin products. These inventions illustrate how close the chemical and engineering trades are allied, necessarily so in these days of modern scientific research.

Doulton and Co., Ltd.

AS a result of extensive researches, Doulton and Co., Ltd., can now supply white chemical stoneware, and also a ware with a water-absorption of nil. Chemical stoneware has a long and worthy past history, and recent developments show that further advances must inevitably result from the increasing collaboration between the chemist and chemical engineer, on the one hand, and the ceramist on the other.



Pipe-line, tank and other plant in white chemical stoneware.

Chemical stoneware is made in England from English raw materials; the great war revealed the folly of depending on foreign supplies of essential materials in the construction of chemical plant. Stoneware "bodies" have a great range of adaptability for the manufacture of plant of all sizes and shapes. Chemical stoneware is the only material, except platinum, which resists the attacks of all acids, in all concentrations, and at normal and raised temperatures (except hydrofluoric acid). In addition, stoneware is relatively less expensive than many alternative materials, which lack its unequalled resistance to the attack of acids.

Epheta Chemical Co., Ltd.

EPHETA scale remover has proved itself an outstanding product for the cleaning of boiler plants and central heating systems during the past year, state the Epheta Chemical Co., Ltd. Considerable interest has been shown in the automobile world for cleaning cooling systems of internal combustion engines, and, in particular, Diesel engines. The scale remover has been thoroughly tested and approved by the Crossley Premier Engine Co , and tests will shortly be concluded by the London Passenger Transport Board. The great advantage of the Epheta process in this sphere is that a thorough cleansing of the cooling system can be carried out without dismantling the engine or necessitating stoppage of normal working.

Gas Light and Coke Co.

THE Gas Light and Coke Co. continues its development in several branches of by-product manufacture. A Koppers (Sheffield) pipe still plant is being installed, designed to treat 80,000 gallons of raw tar daily, and yield close fractions of naphthas and oils, with accurate control over the quality of pitch and/or road tar made. Additions have been made to the benzole plant to meet increasing demands. Two units of plant on the Barbet system continuously removing carbon-disulphide, with an additional unit for motor spirit, have increased the annual throughput of crude benzole. Further developments on the phenol plant have enabled the marketing of a superior grade of technical m-5-xylenol, in addition to standard resin cresols. To meet buyers' requirements xylenols of specially close boiling point range are offered. Waste gases, containing sulphuretted hydrogen, are being treated in a wet-contact process for the production of high quality acid, instead of being burnt, as formerly, in the spent oxide burners to the detriment of the uniformity of the chamber acid making process.

J. Gray and Sons Ltd.

A YEAR of consistent progress is reported by J. Gray and Sons Ltd., service and supply engineers to the enamelling industry. In 1937 the same policy will be pursued as in previous years, *i.e.*, the maintenance of qualified service staff to deal with enamelling problems and the supply of "everything for enamelling." The increase in the sales of the "Olympia" sifting machine is distinctly gratifying, but the company is convinced that less than one-tenth of the potential market for this machine has been tapped. The fact that they are willing to send the machine on approval to any concern interested amply demonstrates their confidence in this machine to "do the job."

This company had the honour of supplying enamel used in the enamelling of apparatus fitted in the Cunard-White Star Liner "Queen Mary," and they have distributed this Christmas to their friends and customers a limited number of specially prepared 1937 diaries containing data relating to the vitreous enamelling industry; this is the first diary of its kind to be published.

G.V.D. Illuminators, Ltd.

FOR G.V.D. Illuminators, Ltd., the past year has been one of continued progress. This firm canufactures few stock fittings, but specialises in "made to measure" lighting equipment incorporating the well-known G.V.D. patents, and it is in this sphere that rapid progress has been and is still being made. One of the main factors contributing to their rise is their unorthodox approach to lighting problems. They do not regard intensity as a measure of lighting efficiency. Perfect diffusion and absence of glare are in their opinion the ideals to be aimed at in every installation, and it is on their success in this respect that their reputation rests.

During the year the company has developed a very efficient industrial unit for factory use, and a totally indirect lighting unit which is considerably more effective than anything of its type on the market. This latter fitting has recently triumphantly passed some very extensive and exacting tests carried out by certain public authorities. G.V.D. lighting can be adopted in offices, laboratories, board rooms, etc., with efficiency and economy and can be adapted and modified to suit individual taste.

Evans, Adlard and Co., Ltd.

WHILST this firm has nothing spectacular to say about the manufacture of "Postlip" filterings during the last year, they report that they have been steadily increasing their trade. A new price list, just issued, shows several new grades of filter paper.

Haughton's Metallic Co., Ltd.

FOR many years this firm has specialised in pumps for dealing with sulphuric acid, nitric acid and other acids as well as alkalies, corrosives and various mixtures of acid liquors as used in the chemical trades. It now has on hand pumps for various acid manufacturers, as well as dyestuffs and explosives trades. A large number have recently been supplied for use in connection with the production of artificial silk and the pumps manufactured by this house are specially designed in such a way to resist corrosive action and are constructed in acid resisting metal, either the Ironac brand of high silicon iron or regulus metal or acid resisting bronze, according as the need may arise to suit the resistance of any particular corrosive. A noteworthy type of pump which has been extensively developed during this last year or so is the glandless pump, now being made as a power driven plunger pump with either single or double plungers according to the height of lift and displacement required.

Jena Glass Works

IN 1936 a number of improved utensils have been designed by the Jena Glass Works Schott and Gen., Jena, that will appeal to all interested in up-to-date laboratory glassware. The Jena analytical funnels for rapid filtration are now supplied with three thin glass ribs on the outside of the cone to facilitate the escape of air at the junction of funnel and recipient. A faster filtration speed of Jena fritted glass filters of very fine porosity is reached through a filter disc consisting of two layers. The lower layer of medium porosity serves as a support for a very thin layer of finest grade. For high boiling liquids distilling flasks with crop are made. Any liquid which condenses in the neck of these flasks will be collected in the groove of the crop whereupon it flows off through the side arm. The Jena cylindrical separating funnels are equipped with a capillary stem of 3 mm. bore through which a perfect separation of the heavy and light liquid is possible.

The new KPG stirrer has a uniformly ground stirring shaft which runs in a bearing of accurate inside diameter, thus making the usual mercury seal unnecessary.

Johnson, Matthey and Co., Ltd.

THE literature issued by Johnson, Matthey and Co., Ltd., during the past year bears witness to the very considerable development which has taken place both in the products available and the methods of marketing them. Further research on the subject of silver solders and their application to specific industrial requirements has resulted in the addition of several other recommended alloys to the previous list, and a further substantial increase in sales.

An investigation into the requirements of the electrical in-

dustry has revealed a number of new uses for precious metal contacts and, as the result of research and experiment conducted in their various works, contact bi-metal is now being produced in various shapes and forms to meet a variety of special electrical contact requirements. Considerable study has been given to the manipulation of radium, and the specially equipped laboratory has been further extended to meet the growing needs of this important department.

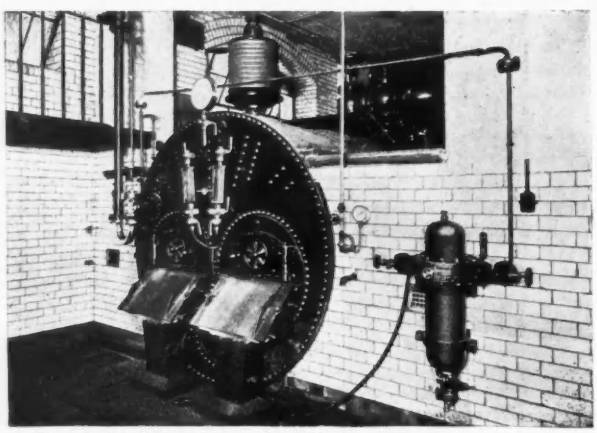
They report that there has been a constant demand during the year for various precious and fine products for use in television research and experiment. Among the new products included in the manufacturing programme are platinum catalysts for automatic gas lighters and transfers for firing on glass. Both of these products have given rise to the need for new departments.

Overseas development during the past year has necessitated the opening of a further Canadian branch at Montreal. Despite foreign trading and exchange restrictions, export figures for a number of products show appreciable increases. In the last few weeks of 1936 work has commenced on the scheme for the rebuilding of the whole of the offices at Hatton Garden.

Kennicott Water Softener Co., Ltd.

ESTABLISHED for over 40 years, the Kennicott Water Softener Co., Ltd., have installed many of the largest water softening plants in the world. During 1936 they have taken up the manufacture on a large scale of domestic water softeners, and their latest range of domestic water softeners are of high efficiency, sound construction and excellent finish.

The company has also developed a patent dejector, which is undoubtedly the simplest and most economical apparatus on the market for maintaining a boiler free from

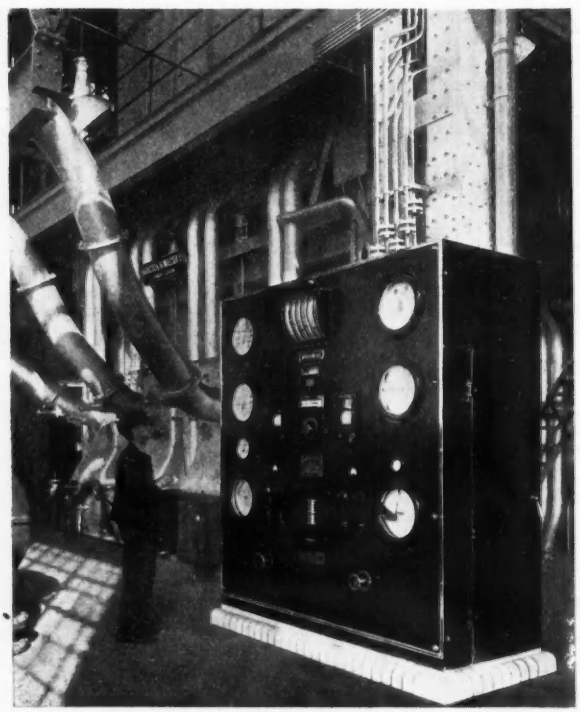


Kennicott Dejector as installed at the War Office.

scale. This apparatus is specially adaptable to isolated boilers, where a central water softening plant is not convenient to instal. Moreover, where there are one or two boilers the installation of dejectors is very much less costly than the installation of a water softening plant. The accompanying illustration shows a Kennicott dejector as installed. The only chemical used in this apparatus is soda ash, and the apparatus maintains a hardness of zero degrees in the boiler and definitely prevents the formation of scale or the collection of mud in the boiler. There are already over 2,600 dejectors installed, which indicates the popularity and efficiency of this apparatus.

George Kent, Ltd.

WITH regard to the coming year George Kent, Ltd., have every reason to believe that an increasing number of uses will be investigated and established for their new Multelec instrument. This instrument is already well in production and the plant laid down for it is working very satisfactorily. There are also excellent prospects in various industries for automatic boiler control which has proved so successful both in power stations and industrial steam raising plants in reducing the fuel costs and improving firing conditions and



Boiler control panel recently supplied to Imperial Chemical Industries, Ltd., by George Kent, Ltd.

the life of boilers. It is hoped that the extensions recently carried out to the company's instrument assembly and testing shops will enable them to shorten deliveries while receiving an ever-increasing volume of business.

John W. Leitch and Co., Ltd.

A RANGE of very interesting products has been introduced by John W. Leitch and Co., Ltd., in their Solunaptos products, which are proving of considerable interest to users of the A.S. type of naphthols for the production of azoic colours on cotton and viscose silk. These products can be supplied in paste or powder form for most of the range of naphthols, and have a definite advantage of ease of application, all that is required being to boil the product up with water and dilute to any desired strength. The solutions produced from these Solunaptols have good stability, and the dyeings obtained possess good fastness to rubbing.

Metal Propellers, Ltd.

AN increasing demand in 1936 for stainless steel plant of all kinds is reported by Metal Propellers, Ltd. A large new shop was brought into commission early in 1936 to increase the space available for stainless steel tanks and kindred work. Additional equipment has also been installed to cope with the rapidly growing demand for welded stainless steel tubes. Coils made of 5 inch and 6 inch diameter stainless steel tubes are now available for the first time. Vacuum pans and stills of various sizes made of stainless steel, where in contact with the product, are becoming more popular as their advantages in respect of a pure product and easy maintenance are more widely realised. While a large proportion of the output of their works has been taken by the food trades, many contracts have been carried out in stainless steel on account of its resistance to corrosion, *e.g.*, for nitric acid and similar difficult liquors. Dyeing machines in stainless steel are making rapid headway.

Kestner Evaporator and Engineering Co.

THE accompanying illustrations show part of an installation which the Kestner Evaporator and Engineering Co., Ltd., completed during the year for the manufacture of milk powder. Fig. 1 shows the lower part of the Kestner patent triple circulation high vacuum evaporator, which is a new type evaporator recently developed for the handling of materials which are extremely sensitive to heat. The whole of the contact of this plant is constructed in stainless steel, and the principal feature of the evaporator is the long period of

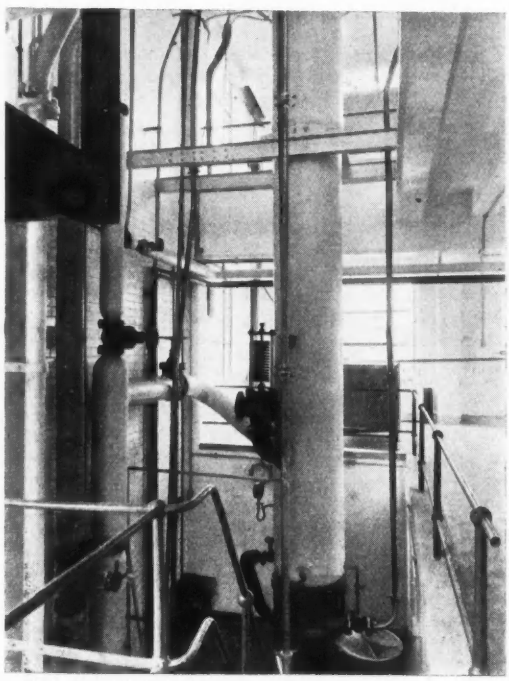


Fig. 1. Patent triple circulation high vacuum evaporator.

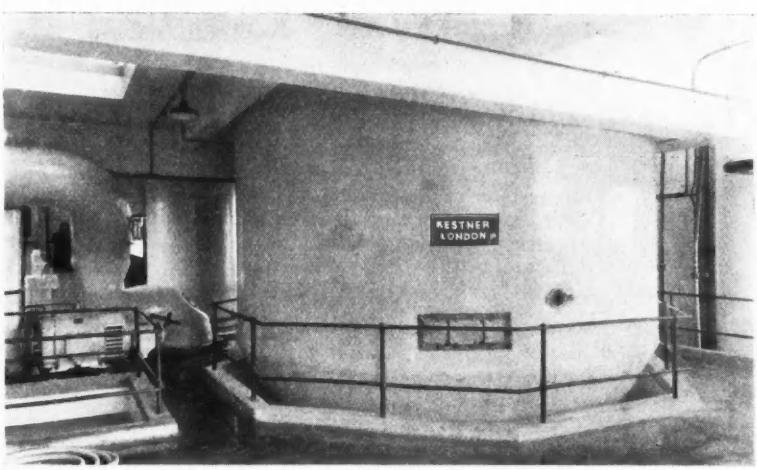


Fig. 2. Kestner patent spray drier.

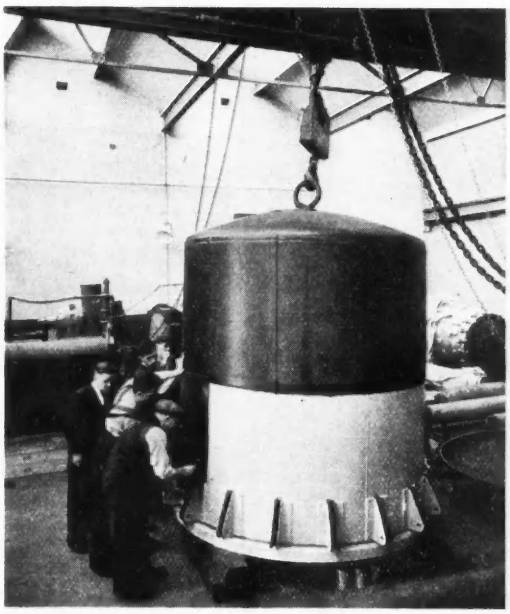
regular running with a steady output of concentrated milk which can be obtained by virtue of the special arrangements for milk circulation and the low temperature which is maintained throughout. After the milk has been concentrated it passes on to the Kestner patent spray drier, the central part of the drying chamber being shown in Fig. 2. Here the milk is reduced to a powder, this operation being carried out also at very low temperature and with short time contact.

Moritz Chemical Engineering Co., Ltd.

DURING the past year this firm has been very successful in introducing a new turbo-agitator of the Moritz patented system, which has given high satisfaction and is being taken up extensively by laboratories and chemical manufacturers.

David Moseley and Sons, Ltd.

DURING the past year David Moseley and Sons, Ltd., have considerably enlarged their hose department, and when this is finished the floor space will be approximately doubled.



High Temperature Acid Tank lined and covered with rubber.

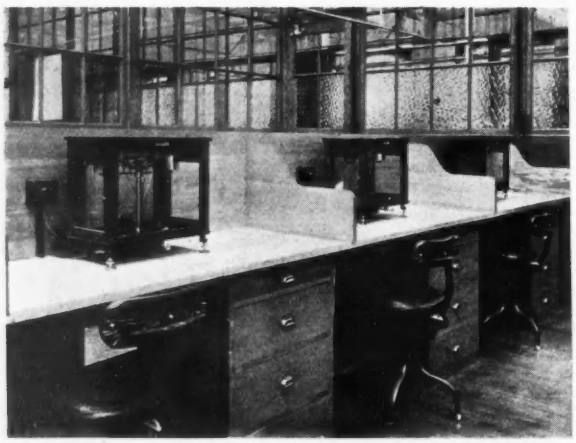
The accompanying illustration shows a tank for handling acids at a high temperature in course of being lined and covered with rubber

Phosphates, Ltd.

THE British patent rights of a new water softening process, which has found much favour on the Continent and is known as the "Budenheim" process, have been acquired by Phosphates, Ltd. It is expected that this process, which is based on the use of trisodium phosphate as softening agent, will be of great service, especially for high pressure boilers, since it is easily controlled and produces completely softened and well condition boiler feed water under conditions which involve great economy in the use of trisodium phosphate. For the purpose of familiarising boiler plant owners with the advantages of this process, Phosphates, Ltd., have opened a water softening department, which supplies any technical information that may be required in this connection and is able to assist in the erection and control of the necessary plant. This department is also suitably equipped for the analysis of raw water and can thus be called upon to examine particular conditions of water supply. Although many processes for softening boiler feed water are in common use, Phosphates, Ltd., feel confident that the merits of the Budenheim process, which is much praised abroad, will in due course be recognised also in England.

L. Oertling, Ltd.

THE outstanding development of 1936 for L. Oertling, Ltd., has been the improvement in design of the prismatic reflecting aperiodic balance, for which there is an ever-increasing demand. Industrial chemists of many of the leading firms have quickly realised the enormous advantage of using the prismatic balance, as compared with the ordinary instrument. The illuminated reading-index avoids all eye strain and the rapidity with which these balances work saves the laboratory staff a considerable amount of time, thus enabling them to devote themselves to other intricate problems which are constantly arising in the laboratory. It is perhaps significant



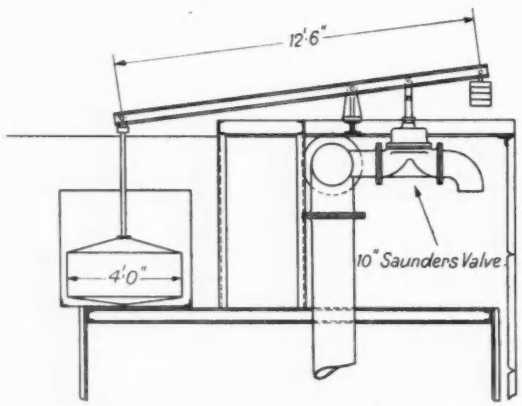
Balance room designed on modern lines and equipped with Oertling balances.

that the firms principally using these balances are the leaders in their particular industry and have a world-wide reputation. These people must have the best; quality and service take precedence to price. This foresight in buying undoubtedly accounts for their being the leaders in their particular sphere of industry. Various research departments have installed these balances covering the food, dairy, iron and steel, artificial silk, tobacco, chemical and oil industries.

A great advance has been made in the production of microchemical balances. The outstanding prismatic reflecting instrument gives readings on the illuminated index to 0.001 milligramme, which is equal to one twenty-millionth part of the capacity of the beam.

Saunders Valve Co., Ltd.

DURING 1936 sales of Saunders valves have again nearly doubled themselves. This increase is attributed partly to



Saunders valve directly operated by float.

general trade improvement, partly to the growing appreciation and partly to exceptional facilities of the makers to give quick deliveries, even of the more unusual types of valve. For example of service, they have just completed an order for Canada for rubber lined valves with special flanges, ten 12 in., fourteen 10 in., ten 8 in., twelve 6 in., twelve 4 in. and nearly 200 smaller valves, all despatched in under four weeks.

They are now doing an interesting business in Saunders valves with "freak" methods of operation, such as hydraulic or pneumatic control, solenoid and float operation. The accompanying illustration shows one of four 10 in. Saunders valves direct operated by floats—surely the largest "plumber's" float valves ever installed. These valves are for the smelter house in a Rhodesian copper mine, where the liquor caused "freezing up" of ordinary valves which had to be discarded. Saunders valves, having no moving parts exposed to the fluid, are particularly suitable for all types of "automatic" operation. For 1937 the company has added lead lining to its programme.

George Scott and Sons (London), Ltd.

THE year now closing has witnessed the translation into practice of several years of research and experimental work on high vacuum distillation, according to George Scott and Son (London), Ltd. A small scale or experimental unit was exhibited at the Chemical Plant Exhibition, as well as a small continuous vacuum band dryer. A large-scale patent high vacuum distillation plant has been put into operation for the production of chemically pure glycerine, this being effected in one distillation from crude. The plant has also been applied to the distillation of resins and fatty acids.

Another landmark in the year is the completion of a large radiant heat dryer under the Scott-Spence patent, and the installation of a number of continuous vacuum band dryers for delicate food products. The year has also seen the completion of a large contract for evaporating plants in pulp-mills in the U.S.S.R. This contract was secured in the face of world competition and two evaporator units under this contract are probably the largest single units operating in sulphate pulp mills. A further notable achievement is the application of the Scott vacuum continuous band dryer to the handling of solid materials. This has been rendered possible by the Reckitt patent seal, the development of which is exclusively in Scott's hands. This arrangement permits of the delivery of solid or semi-solid material into a dryer operating under a vacuum of 29.5 inches.

The Scott patent forced circulation evaporator has met with increasing favour, and plants constructed of stainless steel, nickel and Pfaudler glass-lined steel have been installed during the current year, chiefly for corrosive liquids, foodstuffs and pharmaceutical preparations. The resources of the organisation with which Scott's are associated are probably unique in that the organisation is equipped with foundry, boiler works, alloy fabricating plant, devoted to nickel, Inconel, monel, copper stainless steel, etc., that equipment including the largest spinning lathe in the country.

Sofnol, Ltd.

THIS company reports that it has had an extremely busy year and has had to make further additions to its plant in order to cope with the required increased output. All departments are working at full pressure and additional hands have had to be engaged. This is attributed to the general increase in trade throughout the country, as the water softening materials which it manufactures goes to all classes of industry and, as business increases in these industries, this is reflected by greater demands for its products. The company has booked many running contracts covering the whole of 1937, and anticipates that it will be just as busy in the coming year as during 1936.

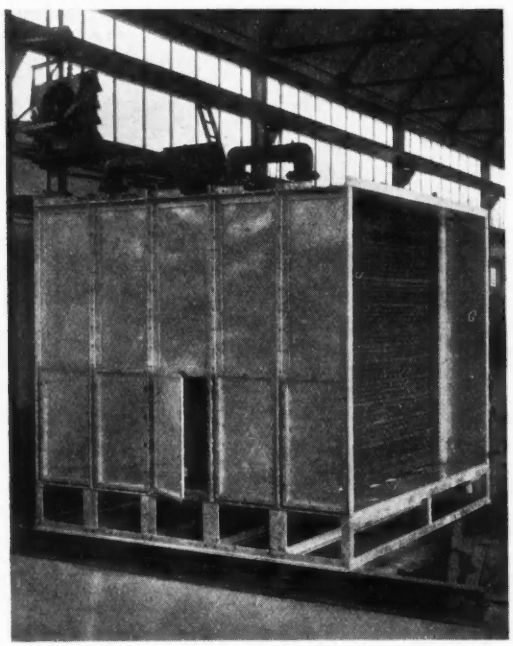
Staveley Coal and Iron Co., Ltd.

THE sodium chlorate plant of the Staveley Coal and Iron Co., Ltd., is now in operation. Difficulty in getting material delayed the completion of the plant considerably. Trade

during the past year has continued to improve and there are indications that the textile trade has shared in the improvement. The demand for chlorine and chlorine products has been good and there seems to be a strong tendency towards the increased use of chlorine for water purification purposes, and it is also being used with great success to stop the growth of algæ in the condenser tubes at many of the large electricity generating stations.

The pitch market has been weak, but most of the other tar products markets have been good, and naphthalene rose to a giddy height early this year. The naphthalene market, however, has eased although the supply cannot yet be considered to be plentiful. The tenseness of the naphthalene situation early this year arose from the fact that export of German naphthalene was restricted owing to the fact that it was required for use at home.

Spiral Tube and Components Co., Ltd.



Air Cooler for use with brine. Each section has inspection door and condense tray. Duct size, 10 ft. by 8 ft. high. Made by The Spiral Tube & Components Co., Ltd., and awaiting despatch.

Wild-Barfield Electric Furnaces, Ltd.

THE demand for electrically heated furnaces for laboratory use and other purposes in the chemical industry is still on the increase, due to the many advantages offered by electric heat over fuel-fired furnaces, reports Wild-Barfield Electric Furnaces, Ltd. The most popular type is undoubtedly the small rectangular muffle with dimensions 19 in. by 7½ in. by 5 in., for temperatures up to 1,000° C. For purposes where higher temperatures are required it is usually necessary to employ furnaces with recrystallised carborundum heating elements which can be used up to 1,400° C. These furnaces are, due to their construction, more expensive than the nickel-chromium wound muffles for the lower temperatures. When tube muffles can be used for such purposes as heating boats, etc., these higher temperatures can be obtained by employing platinum as the heating element.

In a tube muffle recently introduced for temperatures of 1,150° C. the tube itself forms the heating element. In this furnace the tube is of 80/20 nickel-chromium plate bent round and welded to form a tube. At the ends of the tube are welded lugs which are connected to the secondary of a small transformer. A voltage of the order of two volts, according to the size, is applied to the ends of the tube. As the tube itself forms the chamber there is very little difference in temperature between the element and chamber temperatures. This is not the case with wound refractory tubes, which limits the temperature in the case of nickel-chromium wound tubes to 1,050° C. The main advantages of electric furnaces in the laboratory are cleanliness, uniformity of temperature, closeness of control and low running costs, all of which show their superiority over fuel-fired equipments, and which are being appreciated more in the chemical industry.

Technical Research Works, Ltd.

THIS firm has introduced a new Bolton and Williams colorimeter to meet the widespread demand for an instrument independent of individual idiosyncrasies. By eliminating the human element they enable all observers to record automatically identical readings of the colour of any transparent liquid or opaque surface. They incorporate, as a special feature, a filter for the removal of infra-red (heat) rays from the light employed: without such a filter no true measurement of colour is possible by photo-electric means, since photo-electric cells respond to both heat and light. Standardisation of the light source is unnecessary. The instruments measure colour in terms of the percentages of light of various narrow wave-bands absorbed by a given depth of liquid or reflected from plane surfaces. One model is designed for the colour measurement of transparent liquids and may be used for colorimetric determinations, such as the antimony trichloride test for vitamin A, and the determination of very small traces of iron by the thiocyanate reaction. Another model may be used in connection with opaque plane surfaces, powders, pastes or opaque liquids, and the instrument is so sensitive that it will readily distinguish between colours so close in quality and hue as to be barely discernible by the eye.

The Thermal Syndicate, Ltd.

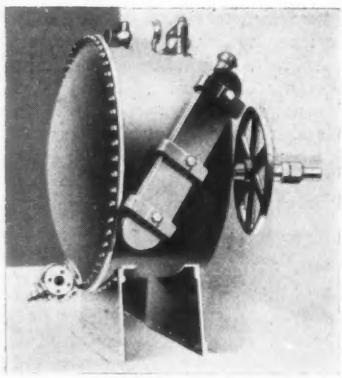
FOLLOWING the production last year of pure alumina ware for laboratory use, the Thermal Syndicate, Ltd., have contained the development of such highly resistant refractories and are now manufacturing fused alumina. This new material has special properties of interest to manufacturers and users of refractories and to those interested in abrasives. It is available to order in two qualities, pure (99.9 per cent. Al_2O_3) and R.B. (87.5 per cent). as lumps or crushed to the grading of coarse sand. Another product—fused magnesia—having high electrical resistance and high thermal conductivity for a refractory product, is continuing to be produced for an expanding market.

Production of the older well-known product, Vitreosil (pure fused quartz and silica) has benefited by the generally increased manufacturing activity during 1936. For example, several chemical manufacturers have replaced with Vitreosil old absorption systems for hydrochloric acid, and others have extended existing installations. A unit of the new Vitreosil direct fired tower concentrator installed in an English works is operating to the anticipated high efficiency. Transparent Vitreosil is finding increasingly important uses, for instruments of high precision and, as tubing, for the new mercury discharge lamps of high lighting efficiency about to be introduced for public lighting.

Wolf Keene and Co.

ROTARY vacuum filters made by Wolf Keene and Co. have met the demand during the past year from tar distilleries, chemical, food product and other works requirements. The company has also supplied equipment for flocculation and thickening, and continuous dryers. For the filtration of phosphoric acid a non-metal non-corrosive drum construction, entailing a new design, has been very successful. Attention has also been given to the design of pressure filters of the totally enclosed and long period working type and also a multi-leaf auto filter.

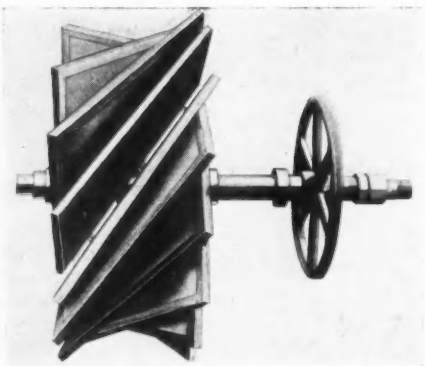
Briefly described, the multi-leaf auto filter comprises a series of leaves, usually all metal, which are in hydraulic communication at their edges with a hollow shaft around



Multi - Leaf Auto Filter and internal mechanism. Wolf Keene & Co.)

which they are spaced and carried equally apart at an angle, and housed inside a casing suitable for a pressure of 30/50 lb. per sq. in., in which the liquid to be filtered is pumped.

The filter has been designed to provide in a simple and quick manner, not only accessibility of the filter leaves for renewal of the filter medium, but also thorough cleansing with but one spray wash in operation. The filter case comprises a closed ended shell with an inclined door situated on the peripheral wall, whereby any one filter leaf may be removed by rotating the assembly of leaves and relinquishing the pressure on the clamping bars fitted to secure them in place; a three-way cock is fitted to the casing bottom for the feed and drainage connection and also wash discharge. This arrangement of the filter leaves renders a perfect cleansing possible and entire removal of the extraneous matter from the casing bottom.



The working of the filter is by the usual pump feed, and upon reaching maximum pressure, indicating that the filter surface requires cleansing, the pressure relief valve provided will automatically open. The next operation is to shut off the feed supply by a turn of the three-way cock, and opening the drainage outlet to return feed tank supply, opening also the vent provided on the casing top. Upon completion of the return feed drainage operation this is followed by a further turn of the three-way cock to wash discharge, the spray wash is then turned on and the filter leaf assembly rotated inside the casing by a hand wheel provided for the smaller size of filters, and by power in the case of the larger size machines.

The filters can be constructed in single, double or quadruple phase of leaf assembly and up to 1,000 sq. ft. total area. Their application, apart from sugars, syrups, juices, jellies and vegetable products, are also favourable for filtering thin suspensions, water, hot supersaturated liquors, slimes, oils, spirit, etc.

An extension to works facilities is envisaged by Wolf Keene and Co. for the coming year, and the manufacture of an increase range of pumps and filter plant equipment.

Mono Pumps, Ltd.

THE outstanding development of the past year for Mono Pumps, Ltd., has been the development of the company's export trade. The export director spent some six months conducting an aerial tour of Africa in order to develop the export sales of the Mono pump and received a favourable reception from this territory. In many instances large orders for general pumping equipment have been placed and extensive orders for specialised equipment. Lever Bros. in Natal have been supplied with a pumping set for handling soap lyes, vegetable oils, etc., and pumping equipment has been supplied to the Castle Wine and Brandy Co., for the handling of wines, spirits and food extracts.

Todd Brothers

THE past year has been fully up to expectations in trading, and the arrangement made to meet the estimated demands have proved of great benefit to customers. The company is of the opinion that business in 1937 will exceed that of 1936, and arrangements have been in hand for some time to ensure that customers' requirements in regard to deliveries and design will be adequatelay fulfilled.

Chemical Market Conditions in 1936

Upward Trend of Prices

MARKET conditions for general chemicals during 1936 have been more or less steady, and while there has not been an outstanding amount of new business, most buyers have increased their consumption to an appreciable extent. Generally speaking, the trend in the chemical market has been an upward one, improving slowly. There were no outstanding matters of moment, although there has been a slight increase in imports despite heavy tariff duties imposed.

The year began with the market for several articles unsettled by the absence of supplies from Italy, and later on, the disturbed political conditions abroad from time to time, together with the departure by France and Holland from the gold standard, caused uncertainty which rather upset both import and export business for a time. The price tendency throughout the year has been very steady, with gradual advances due to increasing costs of raw materials, coal, etc.

In many cases, the surplus supplies of natural commodities and raw materials which have been overhanging the market for a considerable period are gradually being eaten up, with the result that products made from these materials are at present much higher than at the beginning of the year, and with the general rearmament in so many countries, it would appear that demands are likely to increase as time goes on.

A few articles exceptionally have been disturbed by threats of increased competition, partly from Japan, but generally speaking, prices have not been affected very much by this.

Lead, copper and zinc products have advanced considerably in sympathy with the increased metal prices. For instance, red lead, which started the year at £32 per ton for two-ton lots, is to-day £39. Rosin also has practically doubled in price, to-day's figure for American "G" being approximately 24s. against about 12s. per cwt. early in January; but apart from such exceptional changes, the general level of prices, after various fluctuations during the period, has not really altered a great deal. Practically the only reductions during the twelve months are: Acetate of soda, about 15s. per ton down; white powdered arsenic, about £2/£3 per ton down; chlorate of soda, ¼d. per lb. down; permanganate of potash, ½d. per lb. down; prussiate of potash crystals, 1¼d. per lb. down.

It is reported from Glasgow that contract prices for the first half of 1937 have mostly been fixed, generally on the same levels as current figures, though a few articles are slightly dearer for next year.

Fairly steady conditions have prevailed in the Scottish

coal tar products market. There has been an absence of wild price fluctuations, and in the case of most of the lighter materials, *e.g.*, B.S.I. creosote, washed oils, solvent naphthas and high flash naphthas, the values reported to-day do not differ widely from those of this period of last year. A noteworthy and pleasing exception to this general rule, however, is cresylic acid which was selling with difficulty in January round 1s. 3d. per gal. (dark 97/99 per cent. grade), and to-day is in regular demand at 2s. 5d. to 2s. 8d. per gal. This appreciation in value has been steady throughout the year, and indeed, has been quite prenomenal in the case of the pale 99/100 per cent. grades containing a high meta-cresol content, which are now commanding in some cases as much as 4s. per gal.

This brighter state of affairs may be attributed to several causes; it is at least safe to state that the rapidly developing plastics industry is consuming greater quantities of cresols than ever before. Happily there is no indication of an immediate change in this position, and from the number of buyers still anxious to enter upon forward contracts it would appear that present values will be held well into 1937.

Pitch stands on the gloomier side of the picture. Taking the lower figure of the weekly quotation range as the price of vertical retort tar pitch, it is seen that, over the year, this quality, which represents the bulk of Scottish production, has fallen in value by about 7s. per ton. The relatively poor road tar season and the reasonably stable market for creosote and other oils are two factors which have tended to move manufacturers in the direction of over-production of pitch. With the present high stock position, it seems probable that in the ensuing year the market value may fall further to a still closer approximation to its pre-war level. Apart from this rather dull spot, the general tone of the market, particularly for lighter distillates, is fairly optimistic for 1937.

Petrol Production at Billingham

Output up to November 30

CAPTAIN CROOKSHANK, Secretary of Mines, in reply to a question concerning the production of petrol by hydrogenation at Billingham, and the estimated amount paid in wages to miners for the production of the coal converted into petrol, has circulated the following statement:

By the courtesy of Imperial Chemical Industries, Ltd., I am able to say that up to the end of November approximately 170,000 tons, or about 50,000,000 gal., of motor spirit had been produced at Billingham. The company is not prepared, for commercial reasons, to state the actual proportion obtained from coal as distinct from coal tar oils, which are the only other raw materials used, but they inform me that the proportion was a large one. On the quantity of petrol mentioned the revenue on an equivalent amount of imported petrol would be about £1,670,000. For the reasons given I am not able to supply the information asked for in the last part of the question. It is, however, the case that the total quantity of coal used at Billingham in connection with the hydrogenation plant up to the end of November was 650,000 tons. Practically all this coal came from Durham, and it is estimated that on this quantity the amount paid to miners in wages, including the value of allowances in kind, was about £280,000.

Civilian Gas Masks

No Protection Against Carbon Monoxide

THE Government has now admitted that the gas masks which are to be provided for the civil population, in the event of poison gas being used in air raids, will *not* give protection against all gases. Hitherto, questions which have been asked in the House of Commons have received reply to the effect that these gas masks will be 100 per cent. efficient for all gases. But in reply to a question by Mr. De Chair, on December 17, Mr. Geoffrey Lloyd, Under Home Secretary, stated that the "civilian" type of gas mask "does *not* protect against carbon monoxide," although it "protects against highly-dispersed arsenical smoke."

Following on the remarks of Sir John Simon, when speaking at a luncheon of the Special (Air Raids Precausions) Committee of the City of London on December 18, it would be interesting to know why the efficiency of these gas masks—for Government propaganda purposes—is being demonstrated with chlorine gas, when a mask which protects against chlorine does not necessarily give protection against many other poison gases. Sir John Simon said that, as a test of the efficiency of the new masks, Mr. Geoffrey Lloyd had entered a lethal chamber containing enough chlorine gas to kill a man in three minutes, and he pointed out that Mr. Geoffrey Lloyd is still "a healthy and walking example" of the protection which was afforded by the masks. Such a demonstration is certainly no proof of the 100 per cent. efficiency of the masks, and in view of the admission in the House of Commons, this matter of gas masks for the civil population should become a subject for public inquiry.

Lord Nuffield's Christmas Gift

£2,000,000 for Distressed Areas

THE business community can rejoice that one of their number has made such a handsome Christmas gift for the relief of economic distress. We refer, of course, to the £2,000,000 which Lord Nuffield has given to the distressed areas. THE CHEMICAL AGE has more than once expressed the view that the cure of the special areas is primarily the responsibility of private enterprise. This view is endorsed by Lord Nuffield who, in announcing his latest gift, stated that "the Government has done, and is doing, all that is possible within its limited sphere," bearing in mind the "limitations necessarily involved in the expenditure of public money authorised by Parliament." Moreover, the three trustees chosen to adminster the new fund are all business men of wide experience. Mr. Nigel Campbell is a well-known banker and a director of Baldwins, Ltd., and Stewarts and Lloyds. Lord Portal, managing director of Portals, Ltd., and a director of the Great Western Railway, was one of the first commissioners appointed by the Government and is now chairman of the Special Areas Reconstruction Association. Mr. Seebohm Rowntree, chairman of Rowntree and Co., is an expert on social and industrial problems.

The new trust has been formed for "the initiation or support of measures likely to give employment to those living in the areas, as well as of measures designed for the social betterment of those areas." Schemes for permanent recovery, rather than temporary palliatives, are contemplated and it is significant that the capital sum, not merely the interest, is to be used for this purpose. Since the special commissioners are barred from assisting enterprises "operating for profit," Lord Nuffield's fund will perhaps be available to finance private concerns, which at present lack capital for establishing branches in the distressed areas.

Foreign Chemical Notes

Czechoslovakia

MAGNESITE IS NOW IN keen demand and the plants of the Westböhmische Schamotte A.G. and the Pressburger Magnesitwerke A.G. have been working to full capacity for some time to meet orders from abroad.

Finland

THE NEW RAYON MANUFACTURING CONCERN, Kuitu O.Y., the formation of which was recently announced, has already increased its capital from the original figure of 40 million Finnish marks to 120 million.

From Week to Week

THE NAME of Elizabeth Arden, Ltd., cosmetic manufacturers, etc., 5-6 Cork Street, W.1, has been changed to Arden Foundation Co., Ltd.

MR. G. R. GASH, an under-manager, employed by Johnson, Matthey and Co., Ltd., metallurgists and bullion dealers, of Hatton Garden, London, was found in his office on December 17, dying from a shot wound in the head. A revolver was near him.

MR. JOHN C. CLARKE, of Highgate, a director of the British Petroleum Co., who became deputy director of the petroleum executive of the Government during the war period, and subsequently director of the petroleum department of the Board of Trade, left estate valued £27,565, with net personalty £23,117.

GAS MASKS ARE TO BE PRODUCED on a large scale at a new factory to be opened early in 1937. The factory, which has been equipped at Blackburn, is to be opened by Mr. Geoffrey Lloyd, Under Home Secretary. The gas masks produced will be for the exclusive use of the civilian population, and it is hoped that production will eventually be at the rate of half a million a week.

MR. J. E. LAMBERT, of the Explosives Department of the Imperial Chemical Industries, Ltd., lectured on "Mining Explosives and Substitutes" to the last monthly meeting of the Past and Present Mining Students' Association at Wigan Technical College, when he had a crowded audience under the chairmanship of Mr. O. J. O'Nions, agent of Wigan Junction and Bamfurlong Collieries.

WITH A VIEW to obtaining information as to the condition and progress of trades and industries engaged in the manufacture of goods of a class or description which, if they were imported, would be chargeable with import duties, the Board of Trade has given notice that it will require returns in relation to the year 1937 to be delivered in respect of the manufacture in the United Kingdom of goods of any class or description which, if they were imported, would be chargeable with duty under the Safeguarding of Industries Act, 1921; the Finance Act, 1925, Section 3; the Import Duties Act, 1932, Part I; and the Finance Act, 1933, Section 9.

THE NEW FACTORY at Cooley, Riverstown, near Dundalk, for the production of industrial alcohol from potatoes will, it is expected, commence operations early in the new year. The erection of the buildings and the installation of plant is now almost complete. When the factory is working at full capacity, 50 tons of potatoes will be required per day. The production period will be continued for 200 days per year, which will mean that annually 10,000 tons of potatoes will be used. The factory is one of five now under construction in the Free State. The other factories are at Carrickmacross, Ballina, Labbadish and Carndonagh (Donegal).

THE NOMINAL CAPITAL of National Fertilizers, Ltd., has been increased by the addition of £600,000 beyond the registered capital of £400,000. The additional capital is divided into 500,000 4¾ per cent. redeemable cumulative preference and 100,000 unclassified shares of £1 each. The 250,000 preference shares in the original capital have been converted into ordinary shares. At October 28, 250,000 preference and 150,000 ordinary shares had been issued, of which the National Smelting Co., Ltd., held 125,000 preference and 10,998 ordinary shares. Fison, Packard and Prentice, Ltd., held 125,000 preference and 79,000 ordinary; and A. B. Pitcher held 60,000 ordinary shares.

THE SECOND REPORT of the Oil from Coal Committee of the Scottish Development Council says it is apparent that the major problem is of such national importance that it can be adequately handled only by a body representing the widest interests and enjoying the fullest support of all concerned. With this end in view the committee recommends that the best method of carrying its suggestions into effect and of providing the necessary finance for future development should be the subject of a conference of (1) the Commissioner for the Special Areas in Scotland; (2) representatives of the Oil from Coal Committee, the coalmasters of Scotland, the gas industry, the Ministry for the Co-ordination of National Defence, the Mines Department, the Fuel Research Board, and the Geological Survey.

MR. DAVID A. SUTHERLAND, mining engineer and petroleum expert, died at his residence, Fairfield Lodge, Twickenham, on December 8, aged 73. His interest in petroleum began in 1886, when he joined the staff of the Burntisland Oil Co. as mining and technical assistant and within a short time he was appointed the company's manager. His first work in London was as junior partner to the late Mr. G. I. Sneuls, then vice-president of the Iron and Steel Institute. For many years Mr. Sutherland's consulting work in the petroleum industry covered every part of the world where petroleum was known to exist. He was a Fellow of the Institute of Chemistry and of the Chemical Society and a member of the Society of Public Analysts, Iron and Steel Institute, Institution of Petroleum Technologists, Faraday Society, Institution of Mining and Metallurgy and the American Institute of Mining and Metallurgical Engineers.

MR. R. A. ROBINSON, of Birmingham University, has received the degree of Doctor of Science in Chemistry.

MR. SIDNEY ROGERSON has been appointed to take charge of the new central publicity and public relations department of Imperial Chemical Industries, Ltd., as from January 1.

MR. C. NATHAN, assistant secretary of the Ministry of Agriculture and Fisheries, has been appointed a member of the Poisons Board in the place of Mr. H. G. Richardson.

MR. C. E. PROSSER, who has been in charge of the metal sales department of I.C.I. Metals, Ltd., since the company was formed in 1928, has now been appointed a delegate director of the company.

TRIPLEX SAFETY GLASS CO., announces that for the twelve months ended October, 1936, the footage sales of the company and its associated company, Triplex (Northern), Ltd., exceeded 6,000,000, the highest total ever reached. The issued capital of the company is £200,000 in 10s. shares, which stand at £7 15s.

MR. CECIL J. SADLER, J.P., of Durham, chairman of Sadler and Co., chemical works, Middlesbrough, and Sir A. A. Sadler Collieries, Ltd., Lanchester, Co. Durham, died on Sunday in a London nursing home at the age of 68. He was also a director of Bearpark Coal and Coke Co., Ltd., Co. Durham. Mr. Sadler, who was the second son of the late Sir Samuel Sadler, had been connected with the coal trade for 50 years. He leaves a widow, one son and three daughters.

FOLLOWING THE INTERVENTION of Mr. N. Blaney, all employees of the alcohol factory in course of erection at Labbadish, Letterkenny, have resumed work. Mr. Blaney advised the men to return to work pending a conference which he proposed to arrange with representatives of the employers. Later he was in telephonic communication with the Department of Industry and Commerce. The strike, it is stated, resulted from a dispute concerning difference of rates paid to Northern and Free State workmen.

SUCCESSFUL NEGOTIATION of a new agreement affecting wages and conditions of employment in the china clay industry was announced by Mr. J. Donovan, area secretary of the Transport and General Workers' Union, at a public meeting at Camborne on December 19. Mr. Donovan said under the agreement workmen would receive a minimum wages of at least one shilling per hour as from April. The agreement also provided for payment for certain bank holidays, adjustment of rates for piecework, payment of double time for Sunday work, additional payment for men engaged in maintenance work during week-ends, proper rates for youths, and all the things that went to make up a trade union agreement.

A JOINT STATEMENT issued on Tuesday by Imperial Chemical Industries, Ltd., and the National Union of General and Municipal Workers, the Transport and General Workers' Union, and the Mid-Cheshire Salt Workers' Union, says that as the result of a conference between representatives of I.C.I. and those trade unions at which Mr. Charles Dukes, on behalf of the latter, stated the case for a general advance of chemical workers' wages, it has been agreed that adult male chemical workers' wages shall be increased from January 4 by ¾d. an hour (3s. a week to day men and 3s. 3d. to shift men). The rates of piece workers, females, and juveniles, are also being adjusted. This advance in wages will affect approximately 28,000 workers in various parts of the country.

Commercial Intelligence

The following are taken from printed reports, but we cannot be responsible for any errors that may occur.

Receiverships

MEDWAY SYNTHETIC PRODUCTS, LTD., Medway Chemical Works, Pier Road, Gillingham, Kent. (R., 26/12/36.) H. Kidson, chartered accountant, Central House, 45 Kingsway, W.C.2, was appointed receiver on December 2, 1936, under powers contained in debentures dated August 18, 1936.

Companies Winding-up Voluntarily

BREMNERS' CHEMICAL COMPOUNDS, LTD. (C.W.U.V., 26/12/36.) By extraordinary resolution, December 14, 1936. Mr. Arthur Richard Cormack, of 36 Basinghall Street, London, E.C.2, appointed liquidator.

New Companies Registered

F. W. Green and Son, Ltd., Percy Road, Aylestone, Leicester —Registered November 30. Nominal capital £1,000. Manufacturers' agents and chemical manufacturers, etc. Directors: Frederick S. Green and H. Adams.

Metallurgical Section

July 4, 1936

Colouring Steel by Oxide Films

THE colouring of steel by means of films of oxides or iron formed on the surface has been a subject of frequent inquiry, the well-known temper colours formed by heating steel to a temperature several hundred degrees above room temperature being of special interest. These colours range from light straw to blue, the latter being the colour most frequently desired. This tempering treatment frequently has as its chief object the securing of suitable physical properties. Often, however, colouring itself is the object in view, not only for ornamentation but for securing a certain degree of protection against corrosion. The prevalent opinion is that the temper colours depend only on the temperature, blue requiring the highest temperature and yellow the lowest temperature. Experiments at the National Bureau of Standards in the United States, however, indicate that the colour obtained is greatly influenced by the length of time that the material is maintained at certain temperatures. This relationship between time and temperature is now being investigated, and it has been noted that the time and temperature required also vary with the composition of the steel. Temper colours, of course, are due to light interference by an oxide film of varying thickness. The yellow colour is due to interference and extinction of light of relatively short wave length; blue to extinction of light of longer wave length, a thicker film being necessary.

The thin films which form on the surface of most metals by oxidation are most conveniently studied by means of electron diffraction. The film on aluminium, which is most effectual in checking further oxidation, has been shown at the National Physical Laboratory to be nearly amorphous; most other metals form crystalline oxide films. Brass, when heated in air, is coated with a film of cuprous oxide at temperatures below 400° C.; at higher temperatures zinc oxide appears. When aluminium is added to the brass the oxidation is checked, and it is not possible to detect crystals of aluminium oxide, suggesting that it is the amorphous layer of that oxide which has the protective effect. The oxide film on molten metals has also been recently studied at the National Physical Laboratory, tin giving the most satisfactory results. Here it is the rate of oxidation which is of most interest, and this proves to vary, not only with temperature and with the pressure of the oxygen above the metal, but also according to the orientation of the crystals of oxide which are formed and which affects the permeability of the film to gases.

Fractures in Metals

THE fracture of metals and brittle materials was the subject of a discussion at a meeting of the Royal Society last month, when contributions were made by Professor E. N. de C. Andrade, Dr. W. H. Hatfield and others. In his remarks by way of introduction to the subject, Dr. H. J. Gough pointed out that although metals are principally encountered in the polycrystalline state, research indicates that the normal deformation and fracture characteristics are associated with the crystalline structure as such. The main problem probably relates to the correct understanding and quantitative definition of the conditions under which fracture is produced: recent work suggests that the criterion is a certain local condition of the crystalline sub-structure, and further, that this criterion is independent of the actual type of applied loading. Plastic deformation is a common and highly important property of metals which theory does not predict; its cause, nature, variation with temperature, and certain associated phenomena such as hardening, strain-hysteresis, afterworking, process of the conversion of strain energy into heat, are likewise very imperfectly understood. Although all deformation and fracture characteristics of metals are reproducible in single crystal specimens and, probably, will eventually be capable of explanation in terms of such, the strength and hardness of a poly-crystalline aggregate are often profoundly modified by crystal size. It therefore follows that the nature and part played by the inter-crystalline boundaries become important aspects of the general problem. The appearance of the fracture surface of any metal may also be varied profoundly according to the type of external loading used.

Oxides and Oxygen in Steel

THE quantity and distribution of the combined oxygen in steel is known to have a profound influence on the properties of the metal, and several laboratories are now co-operating in an investigation of this subject. Generally, two methods of analysis have been adopted. In one, the steel is melted in a graphite crucible in a high vacuum, and the whole of the oxygen is converted into oxides of carbon which may be pumped off and analysed. A high-frequency induction furnace is used for heating, and there is now general agreement that this method is satisfactory. It is also necessary to know the various forms in which this oxygen is held. Of the many methods which have been proposed, the Metallurgy Department at the National Physical Laboratory has adopted that of dissolving the steel in a dry solution of iodine in methyl alcohol, with precautions against oxidation, and making a complete analysis of the residue by microchemical methods. At present this method is only completely satisfactory for steels within a certain range of composition, and for these the details have been worked out, showing that the results are much more accurate than those given by any other method. The possibility of extending the method to other classes of steel is under investigation.

One of the most dependable methods for the determination of free oxygen in steel requires the fusion

of the sample in vacuo, and one difficulty here encountered by investigators is due to the interference of manganese which may be unavoidably present in the sample of steel. Manganese contents as low as 0.24 per cent. have caused appreciable intereference, but it now appears that with the use of present-day apparatus, this manganese interference is not nearly so serious as it was. The employment of high-capacity pumps for the more rapid removal of the gases evolved from the melted sample is said to be the improvement which has been largely responsible for reducing the amount of the manganese interference.

Spectra Investigations for Columbium

IT was in 1801 that the English chemist, Charles Hatchett, discovered a new element in a mineral found in Massachusetts, and named it " Columbium." For more than a century, however, this new element remained a chemical curiosity, neglected alike by physical and technical investigators. Columbium metal of high purity was first prepared in 1929. More recently, the metal has found an important use in the steel-making industry, for, when alloyed in moderate and economical proportions with chromium nickel steels, it inhibits inter-granular corrosion. At the present time at least one ton of columbium is being refined per day and used for this purpose. In consequence, it may not be long before steel analysts using the spectrograph will need a satisfactory description of the columbian spectra. No comprehensive and accurate measurements of wave-lengths appear to have been published, but this deficiency is now remedied by a paper in the May issue of the " Journal of Research," where the conventional arc and spark spectra (throughout the entire range which can be photographed with large spectrographs in air) is described. Wave-length measurements are presented for 5,700 lines, the average probable error being less than 1 part in a million. Such data should facilitate the spectrographic identification and analysis of columbium, and serve as a basis for a further study of spectral structures and magnetic effects.

Stainless Steel Manufacture in America

RUST is said to destroy millions of tons of iron and steel every year, but this tremendous waste is now being steadily reduced by the use of stainless steels, of which there are more than 60 types on the English and American markets. These may be roughly divided into two groups—the plain chromium or stainless steel of the cutlery type and the 18:8 (more or less) chromium-nickel type for corrosion resistance. As made at the works of the Republic Steel Corporation in the United States, only electric arc furnaces are used in melting the raw materials—pig iron, steel scrap, ferro-chromium —for plain stainless steel, or pig iron, steel scrap, ferro-chromium and nickel for special stainless alloys. As chromium volatilises at these high temperatures necessary for the process, the ferro-chromium is added hot (though not molten) at a later stage in the melt, and the 5,000 lb. ingots remain in the moulds for 90 minutes before they are stripped and taken to the soaking pits.

It takes twice as long to roll stainless steel in comparison with ordinary steel. The billets are heavily cropped at both ends, and slabs are cut to the size required (about 1,000 lb. weight). Each slab is then numbered, and is ground (not chipped) to clear it of scale and defects. For strip, the slabs are rolled, annealed, coiled, pickled in acid to remove scale, and cold-rolled, samples being taken for analysis whilst the thickness is gauged. Following the final rolling, the strip is coiled with paper for protection against damage, and is then polished by high-speed buffers and cut to size. Of the original ingot of stainless steel, about one half is scrapped by cropping, pickling, rolling and trimming. Some of the scrap is sold for its alloy content; the remainder is charged into an induction furnace for re-melting and does not go back to the arc furnace that produces the original steel. Samples from ingots, slabs, plate and sheet are tested for grain structure, impact, tensile strength, and corrosion, the last test being a salt spray of 100 hours duration.

Zinc-Coating Steel Wire

THE Bethlehem Steel Co., of Johnstown (Pennsylvania), has formally opened its new plant for the electrolytic coating of steel wire with zinc. This new process is termed " bethanising," and high-purity zinc is used. The two plating cells are 110 feet long and contain 99.99 per cent. zinc in solution. Twelve wires travel through the electrolyte at speeds varying from 50 to 200 feet per minute. The current is 40,000 amperes at normal load, and the anodes consist of a lead-silver alloy. Any thickness of coating may be deposited. Dies are used for polishing and densifying the zinc coating and the coated wire is said to have remarkable mechanical properties.

Protection of Aluminium Alloys

THE commercial development of sheet material for building aircraft, consisting of high-strength alloy sheet bearing a protective surface skin of pure aluminium, constituted one of the notable advances of the past ten years in the aircraft materials field. Following its first large-scale utilisation, periodical examinations have been made to determine the degree of reliability of this material under actual service conditions. The results of the latest examination at the United States Bureau of Standards confirmed the early predictions which were based on laboratory experiments. Although the aluminium protective skin is not immune to corrosion, this very corrosion accomplishes a useful purpose. The protection afforded to galvanized steel by the " sacrificial " corrosion of its zinc surface finds its counterpart in the protection of the underlying alloy by the aluminium. It has, for instance, been observed that when, in certain spots, corrosion has entirely penetrated the aluminium coating, perforation of the sheet has not occurred, because the electrolytic behaviour of the aluminium coating is favourable for a lateral spreading of the corrosive attack rather than deep penetration. Although definite data on the ultimate useful life of the material are not yet available, it is plainly evident that this combination is very dependable from the standpoint of corrosion resistance under all ordinary conditions.

COPPER sulphide, obtained together with ammonium cyanide by heating thiourea or ammonium cyanate or both with copper, is reconverted into the metal in the same apparatus by oxidation to the oxide followed by reduction to the metal, say by means of coke oven gas or by heating with excess of paraffin. (See Specification 438,402, of G. Siegle and Co., Ges., and W. Konig.)

Metallurgical Research at the National Physical Laboratory

X-Rays Reveal the Manner in which Metals Break

THE annual report of the National Physical Laboratory for 1935 (H.M. Stationery Office, 12s. net) states that the laboratory, which was founded at Teddington in 1900, now occupies 15 large buildings in grounds of some 15 acres, with a staff exceeding 600, and that the scientific basis of the light alloys industry of the country—so important in aircraft construction—largely depends on the work which its Metallurgy Department has carried out on the alloys of aluminium.

Dental Fillings

The recent research work on dental alloys has proved valuable in enabling the practising dentist, by following a regular routine, to make the fillings of teeth more permanent. The amalgam used by dentists for filling cavities in teeth is made by mixing filings of an alloy with mercury. The alloy is composed essentially of silver and tin, but smaller quantities of other metals may be added, and many different compositions are actually in use. The mixture with mercury, called an amalgam, remains pasty for a time, but gradually hardens. It must reach a certain strength, take a high polish, remain uncorroded in the mouth, and have other properties, of which the most important is the constancy of volume. A properly made amalgam expands very slightly during setting, to fill the cavity tightly, but afterwards its volume should remain constant.

Research carried out at the laboratory has shown that the composition of the alloys used must vary only within narrow limits. A little too much tin causes too much expansion, whilst too little tin causes contraction so that the filling becomes loose in the mouth. Further, it has been shown that the time of mixing the filings with the mercury and the pressure used in mixing affect the result, so that a uniform procedure should be used.

Manner in which Metals Break

In view of the use of metals in every form of engineering construction, and of the serious consequences which may arise when metal parts break, it is desirable to know exactly what happens when fracture occurs. A research on this question which has just been completed at the laboratory has afforded much new and interesting information. Each individual crystal in a piece of steel—there are from one million to one hundred million such crystals in every cubic inch of the metal—is built up of a regular arrangement of atoms.

As the conditions of fracture must be associated with this crystalline structure, which is invisible to the human eye, X-ray methods have been used to study the changes which lead to fracture; the X-rays are capable of revealing these sub-microscopic changes. A large number of steel specimens have been deformed and fractured under a wide variety of applied forces. In some cases, the forces were sufficiently great to break the metal at one application; in others, they had to be applied millions of times before fracture occurred, while in a third series the forces were only sufficient to change the shape of the specimen, without fracture, even after many millions of applications. The work has shown that, whatever the type of applied stressing, fracture occurs when a definite limiting condition of the crystal structure is reached.

The changes leading to this condition can be described briefly in non-technical language. Consider, for instance, an individual crystal, of size less than one-hundredth of an inch. Before any force is applied the atoms are arranged in parallel planes throughout its volume. When the stress is applied the crystal begins to break up into two distinct types of fragment. It breaks roughly into two halves, and in addition a number of very tiny fragments are formed of uniform size, measuring about one hundred-thousandth of an inch in length. With further deformation the larger fragments again break into halves, with the formation of more of the tiny fragments. The process continues until the crystal is entirely "shattered" into a mass of the tiny fragments, inclined to each other at every conceivable angle. A new fact is then observed: these fragments are severely strained, neighbouring atoms in each fragment being either nearer to or more remote from each other when compared to their original relative positions. Finally, when the crystal is entirely fragmented and the strain in the tiny fragments has reached a limiting value, the metal cracks or breaks.

On the practical side the results of this research are very important. It is shown for the first time that the fracture of engineering components occurring under a great number of methods of straining results in the attainment of one and the same physical state of the crystalline structure. The connecting rod of an engine may run for many years and then, without warning, fall into two parts; or a crane chain may be grossly overloaded and suddenly snap. The first failure—to which the term "fatigue" is applied—may have taken years of time and millions of engine revolutions to produce; the second failure may have been caused in a few seconds. But we now know that in both cases the fracture marked the attainment of the same condition in a number of crystals, *viz.*, the curious state of disintegration described above, at which the material could no longer retain its cohesive properties.

New Apparatus

Certain new instruments for metallurgical research have been devised in the Metallurgy Department. A motor-driven potentiometer greatly simplifies the taking of thermal curves. It is so designed that all measurements of the e.m.f. of the thermocouple are made with the galvanometer undeflected, so eliminating instrumental errors. The instrument is completely automatic, being set in action by a photo-cell each time the galvanometer spot crosses the zero. It is normally used with the Rosenhain plotting chronograph, and then traces thermal curves without the use of tapping keys.

The work of the laboratory on the properties of metals at high temperatures has covered a wide range. A complete study has been made of the behaviour of wrought irons, ingot iron, and carbonyl iron, the last being a nearly pure metal, under various conditions of loading and temperature. These prolonged creep tests are carried out *in vacuo* to avoid complications caused by the penetration of oxygen. The examination of the micro-structure at different stages and after fracture brings out striking differences between these materials, especially in respect of the formation of internal cracks.

An alloy of copper containing nickel and silicon, which undergoes age-hardening, has also been investigated, and as a result it has been found possible to put forward certain generalisations as to the relation between the maximum hardness reached in ageing and the time and temperature. When ageing proceeds during the creep test, the effects of previous heat-treatment are obscured or annulled, and this kind of change affects many alloys subjected to prolonged loading at high temperatures. Several alloy cast irons have also been compared in respect of their scaling when exposed to flue gases, and it has been found that the composition influences not only the rate of scaling, but also the tendency of the scale to become detached. Cast irons containing nickel and chromium have an increased resistance to scaling.

Sintering Practice at a Modern Steel Works

Details of the Installation at Corby

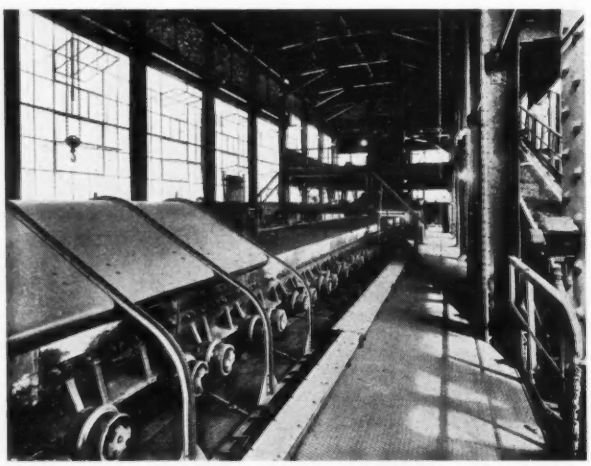
ADDITIONAL details have now been made available concerning the " Dwight-Lloyd " sintering plant at the Corby steel works of Stewarts and Lloyds, Ltd., near Kettering, now largely in operation. This plant deals with iron ore screenings (below ¾ in.), blast furnace flue dust, and roll scale, which on the usual lines are converted into granular particles of suitable size for the blast furnace, the capacity being about 750 tons of sintered material delivered per 24 hours.

Much general information has been published concerning Corby, and it will be remembered the main equipment consists of ore crushing and grading plant, three large blast furnaces (of which two are running), including the sintering plant as well as electrostatic cleaning of the blast furnace gas, by-product coke oven plant of 500 tons of coke per day productive capacity, three basic Bessemer steel converters with hot metal mixers, rolling mill plant, including soaking pits, heavy blooming mill, reheating mill, and a semi-continuous steel strip mill, and a tube-making plant. In addition, all the necessary auxiliaries are provided, including steam generation, power station and blowing plant, water supply, and phosphate slag plant.

The Northamptonshire iron ore used is of a low grade dusty quality, being iron carbonate containing 29-32 per cent. iron, and the annual consumption at Corby on full output is to be about 1,000,000 tons.

The " Dwight-Lloyd " sintering machine, manufactured in Great Britain by Huntington, Heberlein and Co., Ltd., consists in basic principle of a long, horizontal, endless travelling chain of metal carriages or pallets, each having a flat floor formed of firebars, the overall length in the Corby machine being 93 ft., while the pallets are 6 ft. 6 in. wide, giving an effective grate area of 430 sq. ft. On these carriages there is deposited by means of a swinging spout feed a layer about 7 to 10 in. thick of the finely-divided ore and other ingredients mixed with coke breeze and the correct proportion of moisture, using rotary mixers.

Ignition is carried out at the commencement of the travel by an overhead combustion chamber or ignition muffle, fired with blast furnace gas, and the carriages then travel slowly over a series of suction wind boxes, connected by trunking to a fan, so that air is pulled through the material downwards to burn the coke breeze. This gives the necessary temperature for sintering and the product is discharged from the end of the machine as the carriages, forming part of the chain, travel over and downwards at the end on their return journey empty underneath.



Dwight-Lloyd sintering plant at Corby, showing the operating floor of the sintering building, seen from the discharge end with the discharge hood on the left and the mixer and ignition muffle in the background.

The sintered material passes over a stationary inclined screen or grizzly, and the fines below 3/16th in. size are returned to the sintering plant for re-treatment, while the main bulk in the graded condition goes direct to the blast furnace. Also the treatment has the effect of improving the chemical composition of the iron ore smalls, which are raised from, say, 31 per cent. iron to about 42 per cent., because all the water and carbon dioxide are driven off, along with part of the sulphur.

Research on Non-Ferrous Metals in Industry

Standard Tests for Corrosion of Copper

THE programme of research carried out by the British Non-Ferrous Metals Research Association last year is described in the annual report. Details are given of experments to test the " creep " of lead and lead alloys, the metallurgical applications of the spectograph, and the development of a combined degassing and grain-refining process for aluminium castings.

In connection with the study of the corrosion of galvanised hot water tanks, an experimental full-scale hot water system has been installed at headquarters. The tank has been designed to test a wide range of specimens of galvanised iron. By this means it is hoped to gain more information on the type, structure and thickness of zinc coatings best suited to various hot-water conditions. The possible effect of copper pipes on galvanised tanks is also receiving consideration, and a scheme of laboratory work is being planned in co-operation with research on corrosion of copper.

Concerning condenser tube corrosion, the work on the causes of the abnormally rapid pitting action sometimes observed in sea and estuary waters has been continued, and some progress has been made towards the better understanding of this complicated problem. The conclusion that natural sea water may contain substances able to cause a great acceleration of pitting has been largely confirmed, and evidence has been obtained for the view that certain reactive sulphur compounds, produced by various living organisms capable of developing in sea water, are particularly important in this connection. Work on the question of accelerating substances, their origin and the mechanism of their action is being continued.

One of the most important problems of the research is the development of a suitable standard test solution, either a controlled or a treated natural sea water or an artificial salt solution, free from abnormal pitting properties and having the general corrosive properties of a " normal " sea water. Considerable progress has been made, and an artificial sea water has been prepared which complies with the more important requirements. This is already being used for tests on suspected accelerating agents and should be of great service in the further tests on resistant alloys.

Work on the corrosion of copper (water service pipes, etc.) has been mainly concerned with the investigation of the influence of composition of the water and of composition of the metal on the solution of copper (resisting in "green stain") and on the deterioration of the metal. A standard method of test has been adopted, whereby the variation, with time, in the rate at which copper is dissolved by solutions (containing the salts commonly found in domestic waters) is measured. Fundamental tests made with pure copper will form the basis for comparison with all subsequent results with other kinds of commercial copper.

Results of immediate practical value as well as of theoretical interest have been obtained in research on the effect of cast structure on rolling properties. The section of the reseach carried out at Woolwich has been concerned with the rolling properties of zinc and of magnesium in relation to their cast structure. It has provided a satisfactory explanation of the difficulties of cold rolling zinc and why this metal cannot be cold-rolled directly from the cast ingot in ordinary circumstances, although it has been shown that on a laboratory scale cast zinc can be cold-rolled with special and carefully controlled rolling procedure. Similarly, the work has provided an explanation of why magnesium cannot be cold-rolled.

New and useful information has been obtained on removal of bismuth from copper, which should be of interest to those concerned in the smelting and refining of copper. Tests are also in progress to study the effect of antimony on the creep characteristics of soft solders and soldered joints.

With regard to electrodeposition, reports on the effect of oxidising agents and of impurities on nickel deposition have been made available to members; work on the porosity of thin nickel coatings on steel is in progress and a report is in course of preparation.

Preliminary work on the melting and casting of bronzes has been carried out with a view to ascertaining the properties of gas-free pure bronzes. With the technique employed some high density and strength figures have been obtained. A primary object has been the standardisation of methods employed, and it has been found possible to repeat, within close limits, the figures obtained. It is hoped by this means to ascertain accurately the influence of external factors, particularly gas atmospheres, on the physical and mechanical properties of pure tin bronze and phosphor bronze.

The Heat Treatment of Cast Iron

A Survey of Technique and Precautions

ALTHOUGH heat treatment has been applied successfully to steel during the past twenty years, the heat treating of cast iron is of more recent origin. The relative brittleness of cast iron is often a handicap to its use, and whilst malleable cast iron is sometimes specified there is a growing need for an intermediate material—a need well satisfied by heat-treated cast iron. This type of cast iron, according to a report by A. A. Timmins, published in the April issue of the "Bulletin of the British Cast Iron Research Association," combines all the advantages of cheapness and wear resistance with greater toughness, and moreover gives higher strength-weight ratios.

The presence of pearlite as a constituent in the structure of cast iron is now a well-recognised fact. The formation of this constituent, consisting of alternate lamellæ of iron and iron carbide, from the solid solution austenite is accompanied by a definite arrest as shown in any cooling curve taken of cast iron. This is the pearlitic transformation point occurring at 720° to 780° C. A normal steel or cast iron possessing 0.85-0.9 per cent. combined carbon will in general show a wholly pearlitic structure. Pearlite is not so stable in cast iron as in steel, and in some cases, such as in large thick-sectioned castings where slow cooling is possible, or where some graphitising agent is present, the combined carbon will be less than 0.9 per cent. and the structure will show the soft constituent ferrite as well as pearlite. In other cases, such as in thin, rapidly cooled samples, or where a carbide-stabilising element is present, combined carbons higher than 0.9 per cent. will result.

The Influence of Silicon

The heat treating of cast iron is, in some respects, similar to that of steel, but the presence of silicon, which causes instability of pearlite, will introduce modifications. The annealing of medium silicon cast irons below the critical change point produces very little breakdown of pearlite. Consequently, little change in hardness is to be expected. In order to soften cast iron and decompose the carbide successfully, it is necessary to anneal nearer the transformation range. Increased silicon will render the iron more susceptible to annealing despite the fact that the critical point is raised. When hardening cast iron it must be heated above the transformation point before quenching. Commercial cast irons contain silicon, plus manganese, sulphur, phosphorus, and sometimes nickel and chromium. Their influence may be briefly summarised as follows:—

Silicon in normal engineering cast iron may range from below 1 per cent. up to 3 per cent. It is a graphitising element reducing the amount of combined carbon. Silicon also lowers the amount of carbon required for the eutectoid and raises the temperature of the pearlite transformation.

Sulphur and manganese, when in proportions sufficient to form manganese sulphide, are of small importance and may be disregarded.

Nickel is present up to 1 per cent. and has a mild graphitising action (one-third that of silicon). It lowers the critical point and decreases the critical quenching speed.

Chromium is a carbide stabiliser equal and opposite to silicon, tending to inhibit graphitising. It raises the critical quenching point and decreases the critical speed.

Molybdenum is a carbide stabiliser lowering the critical point and decreasing the critical quenching speed.

The lowering of the critical point, carbide stabilisation and the decreasing of the critical quenching speed are factors frequently used to advantage, resulting in easier manipulation and less drastic quenching treatment.

Heat treatment is employed for cast iron with the following objects in view:—(1) The relief of casting stresses; (2) the production of easily machinable cast iron; (3) the production of hard cast irons by quenching, etc.; (4) heat treatment for special purposes.

Relief of Casting Stresses

Many castings, particularly those of uneven section, have internal stresses set up during the solidification of the metal. Such stresses, if not relieved, frequently cause warping and may eventually lead to cracks. The old method of avoiding such occurrences was known as ageing, a process consisting of storing the castings for a time, varying from a few days to months. During this time the stresses between the different sections slowly relieve themselves mainly through daily temperature changes due to weather conditions. Modern mass production methods condemn this on account of the vast amount of time involved. In modern practice the castings are placed on suitable racks and allowed to travel through a muffle, the temperature gradually rising to about 400° to 450° C.

After soaking at this temperature for some hours, depend-

ing on the section, the castings are allowed to cool slowly. It is important to have slow, even cooling, otherwise new stresses will be set up and the castings will be distorted. By treating the castings at this temperature well below the critical point, the metal is rendered sufficiently plastic to allow the release of stresses without causing decomposition of the pearlite. In modern pearlitic castings very little loss in hardness or tensile strength is encountered. Indeed, in very intricate castings release of stress may actually cause an increase in the strength of the casting. In very open-grained irons where the pearlite is comparatively coarse, it is desirable to anneal at about 350° C.

Annealing to Soften Cast Iron

In production work where reduction in machining costs is required, it is necessary to soften cast iron in order to achieve the increased cutting speed. In dense pearlitic irons very little decrease in hardness is noticeable by annealing at temperatures below the critical point. At this temperature and above, the carbide of the pearlite readily decomposes into ferrite and carbon, the latter being deposited to a certain extent on the existing graphite flakes. The usual temperature of annealing is about 790° C. and the operation consists of heating at this temperature in a furnace of the counter flow type for sufficient time to allow of heat penetration. The castings are then allowed to cool slowly to minimise re-solution of graphite and formation of internal strains. In the case of certain alloy cast irons containing small amounts of carbide stabilising elements it may prove necessary to increase both time and temperature of the anneal to accomplish the desired result.

It is often desired to machine or drill holes in light castings where the presence of fins or damp sand has caused the iron to solidify white. Here the hard unmachinable spot is due to the presence of massive free iron carbide as well as of pearlite. Such irons generally require a longer time or a higher temperature of anneal than ordinary irons in order to decompose the bulky cementite crystals. A temperature of 850° to 870° C. is suitable in such cases. These black or dead annealed irons are very soft, having a Brinell hardness of 120 to 140 depending on their silicon content.

Heat Treatment by Quenching and Tempering

This type of heat treatment may be divided into three operations (a) heating for quenching; (b) quenching; and (c) tempering or drawing. The samples are placed in the furnace, slowly heated to about 20° C. above the critical point and then held there until heat penetration is complete. Usually half an hour per $\frac{3}{4}$ in. section is allowed for this soaking. Samples containing free cementite usually require a longer time to ensure complete solution of the carbides. When the desired soaking has been attained the casting is removed and quickly quenched in some medium such as oil, sulphuric acid, or water, depending on the hardness required. Water quenching is often too drastic for cast iron, particularly if the articles are of intricate design, whilst air cooling, except in certain air hardening irons, results in a softening action. Care should be taken to achieve accurate quenching temperatures and also to avoid over-soaking. In steel treatment the higher the quenching temperature the greater the resulting hardness, and this is true to a certain extent for cast iron. This effect, however, is offset by the tendency of alloy irons to form austenite, a relatively soft constituent. Therefore, it is to be expected that the hardness will decrease as the quenching temperature is raised above a certain optimum. Hurst ("Foundry Trade Journal," December 4, 1930, p. 385; December 3, 1931, p. 345) found the best hardening temperature to be 875° C. and inferior hardness resulted by quenching from 920° C.

Additions of carbide stabilisers such as chromium and molybdenum inhibit graphitisation and so permit higher hardness values. Such elements are useful in that they decrease the critical quenching speed. This means that for a certain optimum hardness the quenching treatment need not be so severe, thereby reducing the risk of cracking. This quenching treatment results in a greatly increased hardness (450 to 550 Brinell) due to the formation of the hard constituent, martensite. In this state the iron is much more brittle and the tensile strength inferior to the as-cast material. The maximum advantage from heat treatment is only gained if the hardening operation is followed by tempering. This operation consists of heating the hardened casting at some temperature below the critical point in a lead or salt bath and then requenching in oil or water. By the judicious choice of the tempering temperature various properties may be imparted to cast iron.

Cracking and Distortion

Portevin has suggested the following precautions in the heat treating of steel to prevent cracks, and they may be wisely adapted to cast iron:—(1) the rejection of castings presenting physical defects before quenching; (2) the use of a preliminary anneal; (3) uniform heating; (4) quenching at the lowest possible temperature and as slowly as possible consistent with hardness and other properties desired; (5) the tempering should follow immediately after quenching; (6) the elimination of sharp angles as far as possible. In addition to this it is advisable to have the original casting of as close a grain as possible and a carbon content of 2.7 to 3.2 per cent. High carbon, high silicon irons are to be avoided. When annealing intricate castings for machining purposes it is often advantageous to pack them in small hard coke to reduce distortion.

The hardening of steel by means of nitrogen was first discovered by Dr. Fry in 1923, and the application of this process to cast iron materials was first investigated by the Sheepbridge Stokes Centrifugal Casting Co., Ltd., in 1928. The process is one of case hardening, and consists of subjecting the cast iron to an atmosphere of dry ammonia gas at a temperature of 500° C. The articles to be treated are packed in a gas-tight box made of heat resisting steel, heated in an electric muffle. Anhydrous ammonia gas supplied from a cylinder is fed into the chamber. During this operation, the ammonia is dissociated into its elements, nitrogen being absorbed by the metal and hydrogen which is evolved. Dissociation is affected by temperature and pressure—being increased by the former and lowered by the latter. The ideal conditions have been found to be at a temperature of 500° C. and at a pressure of $\frac{1}{2}$-1 in. water, giving an ammonia dissociation of 30 per cent.

A Special Alloy Cast Iron

A special alloy cast iron known as Nitricastiron is used in the nitriding process—a typical analysis being: total carbon, 2.6; combined carbon, 1.23; Si, 2.58; Mn, 0.61; S, 0.07; Cr, 1.69; Al, 1.43 per cent. This material is susceptible to heat treatment, and also shows distinct air hardening properties. For this reason the castings must be annealed and slowly cooled before any machining operations. Nitriding is most favourable when the castings are in the hardened and tempered conditions. Quenching in oil is conducted from 850° C., and is followed by a tempering or stabilising treatment at 600° C. to relieve internal strain. Precautions should be taken to avoid surface decarburisation during these operations. The articles are treated for 60 to 90 hours, depending on the penetration desired, and then allowed to cool in the atmosphere of ammonia.

Shorterising was brought into use during the last few years for the production of hard surfaces on cast iron articles. An oxy-acetylene flame is traversed over the surface of the material bringing the iron to a temperature above its critical point. The iron is then immediately quenched by means of a jet of water or oil arranged to follow the heating flame. Such treatment produces a martensitic case of appreciable thickness. The hardness is usually in the neighbourhood of 600 Brinell. The process finds application in the hardening of gears for lathes, etc., it being claimed that after hardening in this way the gears show none of the fretting usual to those hardened by other processes.

Metallurgical Section

August 1, 1936

Extraction of Manganese by Electrolysis

THE first report of the Electro Metallurgical Laboratory of the Bureau of Mines, in the United States, which will shortly be published, is anticipated to disclose the details of a method for the production of metallic manganese from its ores by a process of leaching followed by electrolysis. The pure metal so produced is in the form of bright coherent sheets, which are perfectly stable in air. The electrolyte used is a solution of manganese sulphate, since this is the most convenient form in which to obtain manganese by leaching. The secret of success is said to be an ingenious method of maintaining an absolutely constant acidity for the electrolyte. The process is simple and cheap and adaptable to commercial utilisation. It is estimated that the power requirements for electrolytic precipitation will not be more than 3,000 kWh. per ton of manganese. With the large manganese deposits which are located within reach of power at several points in the United States, the power cost of producing high-purity manganese metal from the manganese sulphate electrolyte obtained by leaching may be as low as ten dollars per ton.

Pure metallic manganese is at present prepared by reducing the oxide with aluminium by the Goldschmidt or thermite process, the intense affinity between aluminium and ozygen being utilised as in the production of molten iron or chromium. The metal can also be obtained by the reduction of the oxide with carbon in the electric furnace, but, as in the case of chromium, the product contains a large proportion of carbon and needs refining by re-melting it in the presence of further quantities of oxide. Metallic manganese, as such, is not at present greatly in demand as a commercial article, as most of the output is consumed in the manufacture of steel. Ferro-manganese and spiegeleisen are principaliy the forms which come into the market. Ferro-manganese contains about 78 per cent. of manganese and is chiefly consumed in the open hearth process of steel manufacture; spiegeleisen contains from 12 to 33 per cent. of manganese and is used in the Bessemer process. Both alloys are prepared in a blast furnace by the reduction of a mixture of iron and manganese ores.

Palladium in Leaf Form

IT appears that a silvery white companion for gold leaf has been found in palladium leaf, which is now produced commercially in the United States and also in France. Palladium metal has extraordinary malleability, and may be beaten into sheets only 1/250,000 inch thick. It takes about 35,000 of these sheets, each $3\frac{1}{2}$ inches square, to weigh an ounce. This palladium leaf is tarnish-proof and corrosion-proof, and has a beautiful colour. Either alone, or as contrasting metal with gold leaf, it serves the same purposes as gold leaf. Palladium metal is less expensive than platinum or gold. It is found in small amounts in Canadian nickel ore at Sudbury, Ontario, and with other metals of the platinum group it is refined in quantity by the Mond Nickel Company, at Acton, London. It is high-melting, strong and remarkably easily worked. It alloys with gold remarkably well to make a superior "white-gold," which is highly tarnish-resisting as well as very tough. It also alloys with other metals for special applications, and in the chemical industry it is notable for its power of occluding hydrogen and so giving "catalytic" activity. A process has been devised for plating with palladium to form a highly protective coating for reflectors.

Strontium Minerals in Steel Making

GERMAN strontianite, next to the British mineral, celestite, is the most important source of strontium. It occurs in workable quantities in the Munster district, and mining activities date back to 1870, the largest output being reached with 7,430 tons in 1883. The discovery of celestite in England affected German operations deeply, but until 1914 Russia continued to import about 1,000 tons of German strontianite yearly. Since 1925, when production was 800 tons, the output has been irregular, and the collapse of several large sugar refining concerns that had supported the strontianite mines caused the slump in 1926, when the output was only a few tons, increasing to 65 tons in 1932. New outlets, notably the use of the mineral in iron and steel making as a dephosphorising and desulphurising agent, contributed to a minor resumption of mining, and in 1935 there came a further impetus by the nationalistic movement avoiding imports of English celestite.

Copper-Beryllium Alloys

THE increased industrial use of copper-beryllium alloys during the past few years has caused attention to be directed to the correlation of effects of chemical composition and treatments on expansion. Expansion curves for quenched copper-beryllium alloys, containing 1.33 and 2.14 per cent. beryllium have shown critical regions which may be associated with structural changes accompanying ageing. Stabilisation of the alloys may be accomplished either by tempering or by cold working. It has been found that there is no simple relation between the coefficients of expansion, chemical composition and heat treatment of the copper-beryllium alloys which have been investigated at the State-owned physical laboratories in Europe and America. Generally, it has been found that the coefficients of expansion of copper-beryllium alloys do not differ from the corresponding value for copper by more than 8 per cent. of the latter value, whereas differences for hardness, tensile strength and elongation are considerably greater. For example, the tensile strength of

copper beryllium alloys may be more than four times as great as the tensile strength of copper. The changes in length, density and volume which have been observed for both the quenched and the hard drawn alloys are somewhat larger than the small changes for the aged alloys. The changes in length, volume and density of the quenched beryllium alloys depend upon the temperature and time of ageing. Density decreases with increase of beryllium.

The Iron and Steel Trade

STRINGENT conditions prevailed in pig iron manufacture throughout the past three months and ironmasters fell heavily into arrears with deliveries. The pressure for home deliveries, indeed, was so great that exports, with unattractive prices, became restricted to a mere 8,000 tons per month in comparison with 17,000 tons at the corresponding time last year, thus causing great anxiety to merchants, who feared the breaking off of long-established overseas connections. Difficulties in expanding production are not easily overcome. To modernise a furnace and " bring it into blast " requires at least three months, while firms possessing plant capable of being brought into immediate operation were chary of doing so with coke commanding up to 25s. per ton, and supplies restricted into the bargain. The new batteries of coke ovens which have been started recently should make the position a good deal easier. In the steel branch of the trade the rapidly-increasing production, which reached the record level of 991,500 tons in April and only slightly lower in May and June, was still insufficient for consumers, and imports to the extent of over 40,000 tons per month, against only 17,000 tons in the corresponding part of last year, became necessary. With the bringing into operation of more blast furnaces and scrap steel imports at four times the figure for the corresponding time of the year in 1935, an output exceeding 1,000,000 of steel per month seems possible in the near future.

Corrosion of Mild Steels

Factors Influencing Rate of Attack

" FACTORS Influencing the Rate of Attack of Mild Steels by Typical Weak Acid Media," were dealt with by Dr. T. P. Hoar, M.A., Ph.D. (Cambridge), and Mr. D. Havenhand, B.Sc. (Sheffield), in a paper which they presented at the annual meeting of the Iron and Steel Institute. Several important factors influencing the rate of cororsion of steel in citric acid and citrate buffers have been elucidated and their mechanism studied. Corrosion decreases with increase of *p*H from 1.98 to 4.89. In the more acid soutions, corrosion is accelerated by sulphur in the metal or in the solution, owing to stimulation of the anodic process by dissolved sulphide. It is retarded by tin (and cadmium) ions, which remove soluble sulphide, and by copper in the metal, which probably also removes sulphide. The presence of massive cementite in the metal may accelerate corrosion by assisting the cathodic process. In the less acid solutions all these effects are diminished, and the supply of oxygen becomes an important factor.

Visits to Continental Foundries

A Tour Arranged by the B.C.I.R.A.

TENTATIVE plans have been made by the British Cast Iron Research Association for a visit to several German works in September. This B.C.I.R.A. visit will not clash in any way with the International Foundry Exhibition and Conference which takes place at Düsseldorf from September 16 to 21 (Exhibition to September 27), or the autumn meeting of the Iron and Steel Institute which takes place at Düsseldorf September 21-26, but the two may be made independently and the arrangements will permit tickets at the lowest possible rates. The B.C.I.R.A. party will probably leave London on the evening of September 8, and among the visits will be the Krupp foundries (cast iron, steel, blackheart malleable, non-ferrous) at Essen. The tour will terminate on September 16, the date on which the Foundry Exhibition opens at Düsseldorf.

The total costs of the tour, including travelling out and home, hotel accommodation, etc., should not exceed £20. A minimum number of fifteen will permit reduced rate tickets and a stay of seven days in Germany will enable a 60 per cent. reduction on railway tickets in that country to be obtained.

It may be possible to arrange to visit a leading foundry in Switzerland near the German border, in which case this would be done first and subsequent visits as follows. The Lanz Works at Mannheim is a well-known engineering foundry, and the original home of the process for making castings in heated moulds by the Perlit process. The works of Humbolt Gasmotorenfabrik Deutz, near Köln, produces castings for oil and gas engines and was the works which produced the original Otto gas engine. The iron and brass foundries and pattern shop emplay about 750 men and Silumin is made in the brass foundry. Here cupola metal is duplexed for special purposes in an arc furnace. In the malleable foundry at the Krupp Works about 380 tons per month are annealed in a continuous tunnel oven. The steel foundry makes about 500 tons per month, and the iron foundry about 700 tons per month.

Structure of Metals and Alloys

A Monogram published by the Institute of Metals

SO rapidly has science developed and so mutually contradictory are some of the views held—sometimes even by one and the same scientist—that the smaller fry of science do not know where they are. It is quite possible that recent experimental work by Shankland may bring the whole " leaps and bounds " theory of matter toppling to the ground, and then where are we in the scientific sense? This is where the scientific societies can help us so much. The Chemical Society and the Society of Chemical Industry have, over a long period, published annual reports of progress in pure and applied chemistry. The Physical Society started on somewhat similar lines last year, and now the Institute of Metals has set its hand to an even better and harder task; it has commenced the issue of a series of reports and monographs relating to metallurgy.

The first monograph, entitled " The Structure of Metals and Alloys," is by Dr. Hume-Rothery (Institute of Metals, priced 3s. 6d.). The author is a recognised authority in this field. He gives a clear, concise and accurate account, not overladen with detail, of the structure of metals and alloys in the light of present-day science. The book is not easy reading throughout, but it is as easy as the subject permits. Sections of the book are devoted to the electronic background of metallurgy, the crystal structure of the elements, atomic radii of the elements, primary metallic solid solutions, intermediate phases in alloy systems, and imperfections in crystals. These fairly round off the subject. Each chapter, moreover, is provided with a bibliography of carefully-selected references. The book contains no higher mathematics (knowledge of simple arithmetic, a little trigonometry and less algebra are all that are required of the reader).

Experience with Metals in Swedish Chemical Industry

A Paper Presented at the Chemical Engineering Congress

THE question of protection against various forms of corrosion is a problem of outstanding importance in the Swedish chemical industry as well as in other countries, said Mr. E. Norlin in a paper presented at the recent Chemical Engineering Congress of the World Power Conference. Careful attention has been paid to this question, and investigations have been made in the laboratory as well as on a large scale, with a view to determining the suitability of non-corrodible materials for industrial processes of older date and to selecting materials suited to new processes requiring the use of active chemical substances.

In the range of non-corrodible materials, the metals occupy the foremost place, and among them special ferrous alloys are undoubtedly the most important. These alloys are continually being improved, and their use is steadily increasing.

Resistance to Corrosion

Ordinary iron-carbon alloys, such as wrought iron, with a carbon content below 0.5 per cent., steel with 0.5-1.5 per cent. carbon, and cast or pig iron with a carbon content exceeding 1.5 per cent. are, as a rule, not very resistant to corrosion or rusting. Their resistance is considerable only to alkalies or oxidising agents, *e.g.*, concentrated nitric acid, which make the iron surface passive. For such uses cast iron is more resistant to corrosion than the other iron-carbon alloys, especially if the casting skin is not removed. When using iron-carbon alloys, the surface must be protected by some permanent material, *e.g.*, lead, tin, enamel, or rubber.

The most important non-corrodible alloys are chromium steel, nickel-chromium steel, chromium-silicon steel and high-class iron-silicon alloys. A very thin, hardly visible layer of chromium oxide is usually formed on the surface of chromium-alloy steel.

There are numerous grades of chromium steel, with from 13-22 per cent. chromium. They are not attacked by air, water and vapours, and resist weak chemical agents, such as organic acids, ammonia, petroleum products, and sugar solutions. Chromium steel requires high finish, sometimes even polishing. In Sweden, special alloys are manufactured, consisting of chromium-alloyed pig iron, which are to a large extent acid-proof and comparatively cheap.

The best non-corridible alloys are the chromium-nickel-steel grades, usually termed stainless or rustless steel. These alloys contain, as a rule, about 18 per cent. chromium and about 8 per cent. nickel. They are resistant to air, water, organic acids, dilute sulphuric acid, and sulphates. By adding about 1 to 2 per cent. of molybdenum, increased resistance is obtained to diluted weak acids, as well as to sulphurous acid and bisulphites. This is of special importance for the manufacturer of wood pulp.

The degree of resistance to corrision of stainless steel depends not only on the composition but also on heat treatment and surface finish. For many uses perfect polishing is essential. Stainless steel is particulary sensitive to welding, and great care must be taken to prevent change in composition in the weld seams.

Silicon Steel

Silicon steel, with 12 to 18 per cent. silicon, is not attacked by concentrated sulphuric acid, mixtures of sulphuric and nitric acid, and slightly dilute but not concentrated hydrochloric acid. Iron-silicon alloys with up to 10 per cent. aluminium are very resistant to gases and sulphur at high temperatures.

Aluminium and its alloys stand next in importance to iron in non-corrodibility. As a rule, aluminium is less corrodible than its alloys. The degree of purity of the metal plays an important part in this connection. The grade "Al 98/99," with 98.75 to 98.95 per cent. aluminium, previously marketed, was less resistant to corrosion than the purer grade of aluminium with 99.3 to 99.7 per cent Al now in universal use. A drawback of aluminium is its comparatively low melting point, about 658° C. Moreover, at temperatures above 300-400° C. aluminium softens and its mechanical strength considerably decreases.

In respect of mechanical strength, many alloys, *e.g.*, duralumin and silumin, are superior to the pure metal. Silumin is almost as resistant to corrosion as Al 98/99, but the great majority of hard and tough aluminium alloys are less resistant. The non-corrodible qualities of pure aluminium and the mechanical strength of silumin, or any other alloy, may be combined by rolling two ingots, one of each metal, into a two-layer sheet, from which tanks and other chemical appliances may be made, the aluminium layer being turned inside.

The Eloxal Process

Since the protective layer on aluminium is made up of oxides, a method has been devised, the so-called Eloxal process, of producing by electrolysis a far more efficient oxide layer 25 to 100 times as thick as the natural oxide coating. The Eloxal layer may be made soft and tough so that it will withstand bending of aluminium sheets, but it is porous, and the pores must be filled up with silicic acid from water glass or with various varnishes and colouring substances.

Aluminium is readily attacked by alkalies and soda. The influence of alkalies, however, may be counteracted by sodium silicate or alkali chromate The best way to clean aluminium vessels is to use soda with a small addition of water glass. Ammonia in the form of gas or aqueous solution has little or no influence.

Dilute sulphuric acid (5 to 10 per cent.) and fuming sulphuric acid do not corrode aluminium at low temperatures. Their corrosive action is materially intensified at higher temperature and higher concentration. Nitric acid of 20-40 per cent. strength is strongly corrosive, but more diluted or more concentrated acid is less dangerous. The corrosive action of acid is enhanced by the presence of chlorine, iodine and nitrous gases. The influence of acetic acid on aluminium is negligible at room temperature and independent of concentration. In boiling acid corrosion is most pronounced when the acid is dilute; it is less marked at increasing concentration up to 10 per cent., decreases at a slower rate up to 70 per cent., and is hardly noticeable with concentrated acid.

Hydrochloric acid and chlorides exert a comparatively strong corrosive action on aluminium. Fatty and resin acids corrode aluminium at high temperatures. The same applies to aniline and alcohol, whereas silumin and some silicon alloys are not corroded by these substances when boiling. Aluminium may be used with advantage for equipment dealing with numerous salts, organic substances, and slightly acid solutions.

Advantages of Pure Lead

Pure lead—commercial lead is very pure, containing 99.99 per cent lead—is particularly resistant to sulphuric acid and has, therefore, found extensive use in the manufacture of sulphuric acid. Pure lead has, however, two drawbacks handicapping its application, *viz.*, poor mechanical strength and tendency to recrystallisation, which makes it brittle and probably also less resistant to corrosion. Attempts have been made to improve its mechanical strength and counteract the tendency to crystallisation by adding other substances in quantities so small as not to affect the good qualities of pure lead. Considerable improvement of mechanical strength may be obtained by adding up to 13 per cent. of antimony.

Hard lead, thus produced, is less resistant to corrosion than pure lead, but it is often used for pumps and similar machinery or parts employed to handle sulphuric acid, when good

mechanical strength is required. Hard lead often successfully replaces stonewear for such uses, since stoneware, though very resistant to sulphuric acid, may be readily damaged by stocks and wide variations in temperature. Other additions are 0.02 to 0.08 per cent. of nickel and 0.02 to 0.10 per cent. of tellurium.

For temperatures up to 200° C. pure lead is the best known material for resistance to sulphuric acid. At 230° C. marked corrosion begins. The corrosive action of hydrochloric acid and formic acid on lead depends on the influence of atmospheric oxygen and is, consequently, much stronger in the presence of air. Hard lead is resistant to diluted acids, but its resistance diminishes with increasing concentration and temperature.

The Properties of Copper

The properties of copper depend on the presence of atmospheric oxygen. In vacuum, copper may in many cases provide sufficient resistance to corrosion, but this resistance disappears in the presence of oxygen. Small quantities of sulphur form sulphides on copper surfaces, thus stimulating corrosion. On the other hand, corrosion by organic acids may be delayed by the presence of small quantities of potassium ferrocyanide and kinolinethyliodide. In the absence of air, copper is a resistant and extensively used material for distilling raw acetic acid containing formic acid. Copper is corroded by alcohol and kerosene, but not by benzine or benzol.

Bronze, copper-aluminium and copper-silicon alloys may in special cases be more resistant than pure copper. However, on account of their high cost the use of these alloys is limited to small appliances and to applications where the high mechanical strength of bronze is of special importance.

Nickel, as marketed, is fairly pure—99.4 to 99.8 per cent. nickel—and possesses good resistance to corrosion. It is less resistant in the presence of atmospheric oxygen, but may be rendered less sensitive to this influence by polishing. Like iron, nickel may be made passive, *e.g.*, by treatment with a 58 per cent. solution of fluorine hydride and hydrofluoric acid may be stored and transported in tanks made of passive nickel. Molten alkalies, carbonates, nitrates and sulphates do not attack nickel. Furthermore, it is not attacked by aqueous solutions of alkali sulphates, nitrates, tartrates, acetates, fatty acids and many other organic substances.

Monel metal, containing 67 to 70 per cent. of nickel, 28 to 29 per cent. of copper, and 1 to 5 per cent. of other substances, is similar to nickel in respect of resistance to corrosion, and in some cases even superior to the latter. Nickel-chromium and nickel-chromium-iron alloys are resistant to atmospheric oxygen and other gases at high temperatures.

Metal Coatings

In some cases it may be advantageous from the point of view of cost, as well as for other reasons, to construct tanks, vessels and other equipment of cheap metal having good mechanical strength but not resistant to corrosion, and to line them with a resistant metal coating. This metal lining may be either thin, when it is usually made by electro-plating, or comparatively thick and produced by direct rolling of sheet. These metal linings naturally have the same properties for protection from corrosion as the corresponding solid metals, but their thinness reduces the margin of safety. The ordinary plating methods are lead-plating, tin-plating, zinc-plating or galvanising, and chromium-plating.

Lead-plating of iron containers and parts of machinery is effected by direct treatment with molten lead (dipping) preceded by galvanising. Pore-free linings may be produced by a spray process according to Schoop; lead is said to be particularly suitable for spraying. The thickness of the lining varies between 0.2 and 0.9 mm., depending on the strength of corrosion. For many purposes cheap non-corrodible vessels can be made by lead-lining large or small wooden tanks, the insides of which may eventually be coated with petroleum asphalt.

Zinc-plating, or galvanising, gives excellent protective coatings resistant to rusting as well as to neutral or slightly corrosive substances, but sensitive to more active chemicals.

Tin-plating produces the classical protective coating on copper and iron, so-called tin sheet. Tin and tin coatings are resistant to neutral and organic substances containing sulphur as well as to most organic acids in the absence of atmospheric oxygen. Tin is corroded by alkalies, numerous salts, and oxidising agents. Tin coatings may be made by electro-plating or by spraying. The usual method, however, is hot dipping by direct treatment with molten tin heated to 30° C. in excess of the melting point or to a somewhat higher temperature.

Chromium Plating

Chromium-plating is an important method for industrial purposes. Where iron is concerned it must be preceded by copper-plating. Chromium coatings give sufficient protection against concentrated alkali solutions, fruit juice, sulphur compounds of sulphide character, and neutral salts. Strong acids produce rapid corrosion, weak acids have a less pronounced effect; the same applies to chlorides, some other chlorine compounds, and oxidising agents.

In the manufacture of food products various grades of stainless steel have found extensive application. In a large factory making food products in Stockholm usually stainless chromium-nickel steel (18 to 8 per cent.) is used, sometimes molybdenum alloyed, in the shape of sheets. In exceptional cases chromium steel without nickel is employed.

Extensive tests have been made with various grades of stainless steel, during which hot ham was placed on polished as well as unpolished sheets for considerable periods of time. The tests have shown that ordinary 18-8 per cent. steel, also when molybdenum alloyed and carefully heat treated but not polished, is rapidly corroded, whereas a high degree of resistance to corrosion was shown by polished surfaces of the same material throughout the tests. Only two of the tested grades of steel were found resistant to corrosion when pickled but not polished. It is to be noted, however, that the percentage of alloys was in these cases higher than 18 to 8.

Attempts to store saturated salt solutions in pressed and welded vessels have been unsuccessful. Corrosion began in some isolated points and then rapidly progressed on the same spots, so that the sheets were perforated after 2 to 3 weeks.

Handling Wood Pulp

In the manufacture of wood pulp various materials are used, depending on the strength of corrosion, such as cast iron, wrought iron, copper, acid-proof bronze, lead, as well as stainless and acid-proof steel. Cast iron and wrought iron are comparatively sensitive to corrosion, but so far it has been impossible to replace them by any other sufficiently resistant and cheap ferrous alloy. In the heat exchanger and evaporator tubes in sulphate pulp mills a peculiar corrosion phenomenon takes place, known as "spot corrosion." At first it was believed that this phenomenon was due to roughness of the material, but microscopic and chemical investigations showed that this was not so. According to Professor Benedicks, the cause of this type of corrosion may be that during heating, bubbles of gas are produced in some points of the tube owing to higher temperature or roughness of the surface. It may be assumed that concentration of acid or of other corrosive constituents occurs at these points, producing local corrosion.

Copper, acid-proof bronze, and lead, have long been used in pulp manufacture. These metals are comparatively cheap and may be readily mounted and worked. Furthermore, they possess a scrap value, when worn out, which is comparatively high compared with their first cost. The disadvantages of copper, and to a certain extent also of acid-proof bronze, are their insufficient resistance to corrosion by strong agents such as, for instance, sulphite acid and bleaching mediums, as well as their comparatively low mechanical strength, requiring ample proportioning of al parts exposed to notable mechanical stresses.

Among acid-proof steels, the pure chromium-steel alloys

are resistant to soft water and lyes. They are, therefore, much used for feed-water pipes, evaporator tubes in sulphate pulp mills, knives for beaters and jordans, etc. In contradistinction to chromium-nickel steels and chromium-nickel-molybdenum steels, these grades may be hardened so that chromium steel may be given that mechanical strength which is required in each application.

Pure chromium-nickel steel is not sufficiently resistant to sulphite acid and bleaching liquids and this is but rarely used in pulp manufacture. Chromium-nickel-molybdenum steel, on the contrary, gives very good results in this respect. During a series of comparative tests, steel specimens were exposed to the action of a saturated aqueous solution of sulphur dioxide at various temperatures and pressures. At 150-180° C. and 6-10 atm. the time required for corrosion of a layer of metal 1 mm. in thickness was calculated to be about 6 months for chromium-nickel steel (18-8 per cent.) and about 10 years for chromium-nickel-molybdenum steel (18-8-1.3 per cent.). The last-mentioned steel also resists calcium bisulphite.

In sulphate pulp mills corrosion does not, in general, present any special problems. Here, ordinary wrought iron is quite a suitable material, and there is no reason to use stainless steel, except, perhaps, for evaporator tubes. Acid substances contained in the black liquor, *e.g.*, sulphuretted hydrogen, formic acid, etc., are fairly aggressive to ordinary iron, and evaporator tubes have to be replaced from time to time.

Corrosion Tests

Corrosion tests at 80° C. with condensate from an evaporator gave a corroded layer of 0.25 mm. per year for wrought iron and zero for 13 per cent. chromium steel. As the tubes are exposed to spot corrosion only at one end and within a limited zone, tests have been made on wrought iron tubes to which a piece of stainless-steel tube about 300 mm. long was welded at that end where corrosion usually occurred. It was found that the duration of tubes may in this way be substantially increased. It is advantageous to employ stainless steel tubes for condensers for turpentine oil condensate and for white liquor preheaters.

In sulphite pulp mills the use of acid-proof steel has been steadily increasing during the past few years, and it may be said that the introduction of cooking by circulation and indirect heating have been rendered technically and economically possible by the properties of acid-proof steel. This steel may be utilised for many purposes, *e.g.*, digester fittings, valves, covers and locking devices, acid, gas, and pulp conduits. In the first place, the grades having the composition 18-8-1.3 per cent. and 24-5-1.3 per cent are used, preferably in the shape of castings and rods.

There is, however, a place in the sulphite pulp mill where acid-proof steel does not suffice. It is located between the pyrites kiln and the acid tower. In the pyrites kiln a certain amount of sulphur dioxide is produced, which becomes sulphuric acid in the washing tower, which is maintained at such a high concentration and temperature that acid-proof steel cannot withstand its action. The same applies to piping connecting the pyrites kiln to the washing tower.

Pulp Bleaching Equipment

For pulp-bleaching equipment, acid-proof steel has found extensive use as material for conduits and pipes, beater knives and so forth. Cheaper material may no doubt be used and will give quite satisfactory results, but when working with bleached pult it is a substantial advantage from the standpoint of cleanliness to keep it free from impurities due to rust and verdigris, otherwise readily produced during week ends or similar stoppages.

In the manufacture of sulphuric acid in lead-chamber plants, where nitrogen oxides more or less always contribute to corrosion, the resistance of the lead is proportionate to the degree of purity of the metal. The properties of lead have been discussed above, but it may be added that tellurium lead is said to possess twice as high tensile strength and thrice as high resistance to fatigue as the so-called chemical lead. This material is much tougher and does not become brittle when cold machined. Furthermore, this material is claimed to show greater resistance to sulphuric acid. Comparative tests carried out in a cooler for Glover acid are reported to have shown that the resistance to corrosion of tellurium lead containing 0.06 per cent. Te is seven times as high as that of the best chemical lead. For resistance to nitrosyl-sulphuric acid, the most aggressive form of sulphuric acid in the lead-chamber process, experience seems to indicate that no material advantages have been gained.

In many, perhaps even in most, instances heavy corrosion of lead in lead-chamber plants occurs because the operating conditions are inadequate in some respect or other. Lead is much too frequently accused of being the sole responsible element. A comparatively insignificant modification of operating conditions will sometimes result in considerable decrease of corrosion.

Superphosphate Plant

In the manufacture of superphosphate the problem of corrosion is less important than in the manufacture of sulphuric acid. In treating raw phosphate with sulphuric acid the quantity of the latter must be such as to produce an excess of 4 to 7 per cent. of free acid reckoned as P_2O_5 in the fresh superphosphate. This excess of acid is not dangerous in respect of corrosion so that ordinary iron and steel may be used to construct equipment and appliances which are in contact with superphosphate. This is because the free acid in superphosphate, which mainly consists of phosphoric acid, combines with iron, forming a protective layer of ferrous phosphate in a way similar to parkerising.

Those parts of machinery which are exposed to wear, wear out very quickly, owing, probably to continual destruction of the phosphate layer. As a consequence, rapid corrosion is combined with wear. Among such exposed parts of equipment mention may be made of the knives used for cutting superphosphate after it has left the sulphuric acid chambers. Knives made of stainless 18-8 per cent steel have proved to be three or four times as resistant as hardened knives made of spring steel with 0.6 per cent. carbon. Steel band conveyors for the transport of superphosphate are employed in some mills. On account of the small thickness of the steel band which is simultaneously exposed to corrosion and wear under the action of scrapers and levellers, the duration of normal steel band is comparatively short.

Manufacture of Explosives

In the manufacture of explosives the primary purpose of protection from corrosion is to produce a material resistant to nitric acid and sulphuric acid, as well as to mixtures of these acids at various temperatures and concentrations. Long experience has shown that 18-8 per cent. chromium-nickel steel and 18-8-1.3 per cent. chromium-nickel-molybdenum steel are the most suitable materials for this purpose.

Stainless steel has proved to be equally well suited to the manufacture of nitro-glycerin. Previously, lead equipment was almost exclusively used for nitration and washing, at least in Europe. This material was liable to damage, necessitating frequent repairs and even replacement—always the right thing to do where nitro-glycerin is concerned. Stainless steel appears to be an ideal material for this class of uses.

Ordinary stainless chromium steel and chromium-nickel steel are not resistant to gases containing sulphur. Addition of copper, manganese, cobalt, lead, silicon, molybdenum, wolfram, and titanium had no noticeable effect on the resistance, or even weakened it. Pure aluminium resists gases up to its smelting point (658° C.). Several ferrous alloys containing aluminium have proved partly resistant or even non-corridible.

A combination of aluminium and chromium, with a small addition of nickel or cobalt, seems to be best suited to this

particular case. The aluminium-content of pure aluminium-iron alloys must be increased to about 25 to 30 per cent. in order to ensure sufficient resistance, but this increase tends to make the alloy brittle. The chromium-cobalt-aluminium alloy known as " Kanthal " (22-2-3.5 per cent.) has given the best results. Equally good results have been obtained with two other alloys having a similar composition. Kanthal was, practically speaking, resistant up to 900° C. and the two other alloys up to 800° C. Zinc-plated sheet iron has shown fairly good resistance up to about 700° C., and aluminium-plated iron annealed during a short time when aluminised appears to be equally suitable at least up to 600° C.

The Institute of Metals

Programme of the Autumn Meeting in Paris

THE 28th autumn meeting of the Institute of Metals will be held in Paris from September 14 to 18, by the kind invitation of the Bureau International des Applications de l'Aluminium, with the cordial co-operation of the Chambre Syndicate des Métaux à Paris.

The headquarters of the Institute, and the office of the hon. local secretary, will be at the Maison de la Chime, 28 Rue St. Dominique, Paris, where all the meetings and a banquet will be held. An influential reception committee (of which the hon. secretary is Monsieur J. S. Douchement, a member of the Institute) has been formed to carry out the necessary arrangements.

A special feature of the meeting will be an optional tour, to be made on Friday, September 18, to Rouen, its neighbourhood, and Havre, which will give members an opportunity of visiting a town famous in French history as well as modern metallurgical and engineering works in another part of France.

The meeting will open on Monday, September 14, with the delivery of the 15th annual autumn lecture by Professor P. A. J. Chevenard (corresponding member of the council for France) on " The Scientific Organisation of Factories." This will be followed by an informal gathering of members, refreshments, and a display of cinematograph films of metallurgical interest.

An official welcome will be extended to members in the ampitheatre of the Maison de la Chimie in the morning of Tuesday, September 15, before the beginning of the first session for the discussion of papers. Afterwards, ladies will have an opportunity of making morning visits to places of interest and will later join members at lunch at the Hotel Palais d'Orsay (tickets 4s. each). In the afternoon members and ladies will make visits to works, and in the evening a banquet will be given by the Bureau International des Applications de l'Aluminium.

On Wednesday, September 16, the discussion of papers will continue in the morning (arrangements being made for the entertainment of the ladies meanwhile), and lunch will be served as on the previous day. In the afternoon further visits will be paid, concluding with a civic reception at the Hotel de Ville by the Municipal Council of Paris. In the evening there will be a dance at the Prè Catelan, Bois de Boulogne.

Thursday will be devoted to an all-day motor excursion to Versailles, visiting features of interest.

It is anticipated that there will be a large attendance of members from all parts of Europe. Applications for membership can be received up to August 27, and should be addressed to the Secretary, Institute of Metals, 36 Victoria Street, Westminster, London, S.W.1.

Works visits during the meeting will include: Renault Motor Works, Billancourt; Tréfileries de Vitry (Compagnie Generale d'Electrométallurgie) and Cableries de St. Maurice (Tréfileries and Laminoirs du Havre), both concerned with the rolling and drawing of copper; Société des Phares Marchal à Pantin (electrodeposition of nickel and cadmium); Société Française des Métaux et Alliages Blancs (white metals); Société des Alliages d'Etain et Dérivés à Montreuil s/Bois (tin alloys); Etablissements Lioré à Argenteuil (aviation works); Fonderie de Précision à Nanterre (pressure casting of alloys of zinc and aluminium); Imprimerie de l'Illustration à Bobigny (printing works)

The following papers are expected to be submitted for discussion at the Paris meeting:—G. G. G. Gauthier, " The Conductivity of Super Purity Aluminium. The Influence of Small Metallic Additions." Marquis R. de Fleury and H. Portier, " The Complex Interdependence of the Properties of Alloys and the Industrial Conditions of their Manufacture, Testing and Use." Professor A. von Zeerleder, Dr. Ing., and R Irmann, Dr. Ing., " Mechanical Properties of Aluminium and its Alloys after Prolonged Heating." N. D. Pullen, "An Anodic Treatment for the Production of Aluminium Reflectors." Professor A. M. Portevin and P. G. Bastein, D.Sc., " Mechanism of the Forgeability of various Light and Ultra-Light Alloys." R. H. Atkinson, M.A., and A. R. Raper, M.A., " Metals of the Platinum Group: Ores, Recovery and Refining, Fabrication and Uses, Properties." Professor D. Hanson, D.Sc., and E. J. Sandford, B.Sc., " The Creep of Tin and Tin Alloys, Part I." L. Northcott, Ph.D., M.Sc., " Veining and Sub-Boundary Structures in Metals." A. J. Sidery, Assoc.Met., and B. Evans, B.Sc., " A Note on the Influence of Salt-Bath Heat-Treatment on the Corrosion-Resistance of Duralumin Sheet."

Opacification of Enamels

Use of Tin Oxide

STANNIC oxide is one of the oldest and most used of enamel opacifiers, and because of its suitability for every class of enamel it has received little attention in the technical literature as compared with its substitutes since the conditions under which they are practicable have needed more careful investigation.

According to Technical Publication Series A, No. 42, of the International Tin Research and Development Council, entitled " Opacifiers in Wet and Dry Enamels," which is an account in English of investigations by Dr. Ludwig Stuckert, read before the Society of German Enamel Technologists, The effect of opacifiers on the enamel is not confined to optical differences, but is productive of physical and chemical changes which have important influences on the properties of the enamels. The influence of opacifiers was investigated for both wet and dry enamels, in respect of the coating power of the enamel, its bending strength and heat resistance, its solubility on extraction with dilute acids, and the opacity and lustre after normal burning and overburning.

In firing enamels there is more than a mere developing and penetration of the opacifier particles and occasional dissolution and vitrification of them. Stannic oxide on the whole exerts the most beneficial effects on the properties of the enamel, improving not only the coating power of the enamel, but also mechanical, thermal and chemical properties to a greater extent than any other opacifier. Stannic oxide enamels are stable towards firing and over-firing and do not " boil out " or become foamy, and the superiority of stannic oxide as regards the gloss of the enamel has also been confirmed. The ease of its application and the reliability of its opacification, added to the newly discovered benefits it confers on the enamel in physical and chemical respects, ensure for it the leading place among opacifiers.

Metallurgical Section

September 5, 1936

Aluminium Bronze Foundry Practice

SOME information of interest to chemical engineering regarding present-day methods of working and the application of aluminium bronzes is published by E. Lay, in " Zeit. f. Metallkunde " (1936, No. 3, page 64). Alloying constituents which may be added to aluminium bronzes include iron, nickel manganese, tin, zinc and silicon. The bronzes containing 9-11 per cent. of aluminium are heat-treatable, especially when other constituents are present. Alloys containing less than 10 per cent. of aluminium can be worked either hot or cold; those with a higher aluminium content can be hot worked only.

Satisfactory corrosion resistance towards alkali halides is shown by 4 per cent. aluminium bronze; this alloy is therefore used in considerable quantities for equipment at potash salt mines. The 8-10 per cent. alloys have a much higher corrosion resistance, making them especially useful for chemical plant applications. With the addition of further alloying constituents they are usefully employed for a variety of acid-resisting valves, and also for gear wheels which are exposed to corrosive conditions. The general application of aluminium bronzes for the construction of chemical plant, however, is hampered by unsatisfactory welding, or, in some cases, almost impossible welding. Casting is also rendered difficult, in many cases, by the tendency of the alloys to form oxide skins and inclusions; Lay actually discusses some of the precautions which have to be observed.

At the annual meeting of the American Foundrymen's Association last May, M. T. Ganzauge discussed another aspect of the use of aluminium bronzes, namely, the production of castings to withstand high pressures. Details of foundry practice as applied to the production of castings weighing up to 150 lb. were described for a metal containing 87 per cent. of copper, 10.5 per cent. of aluminium, and 2.5 per cent. of iron. It was stated that pouring should be done as steadily as possible, as agitation of the metal during the pouring operation, or in filling the mould, will cause oxide films to be included in the casting. The agitation of the metal in filling the mould can be overcome by adopting a suitable design for the gates, which should be able to retain dross and thereby prevent it from entering the mould. In the case of large moulds it has been found a useful practice to fill the mould with carbon dioxide gas before pouring in the metal.

Aluminium bronze may contain 5-11 per cent. of aluminium, or 5-10 per cent. of aluminium and 1-5 per cent. of iron. The melting operation should be carried out at low temperature, but should be completed as quickly as possible in order to avoid undue exposure to the furnace gases. For the best results the initial metal should be cast in " pigs," which can be re-melted as required. A mixture of magnesium and manganese sulphate may be used as a flux. According to J. E. Crown, in another paper presented at the same meeting, " chills " are used to permit the production of difficult castings by the control of shrinkage in areas which are inaccessible to proper feeding; for improvement in physical properties at certain parts of the casting; and also for the control of dross which tends to collect on the surface of the metal adjacent to a chill and can be subsequently removed by machining or by grinding.

Direct Production of Steel

INVESTIGATIONS for the direct production of steel have been in progress in the United States during the past year. The Bureau of Mines has been concerned with the utilisation of a re-formed natural gas-air mixture to produce sponge iron. It was some years back that the availability of cheap natural gas in the United States, together with local accumulations of more than ¾-million tons of pyrite cinder (containing upward of 400,000 tons of metallic iron) renewed an attempt to treat such material for the direct production of steel. Previous attempts, using solid carbonaceous materials as reductants, had not proved economic because of local conditions with respect to fuel. Founded on thermodynamic calculations, a process was therefore proposed which consisted of catalytically re-forming mixtures of natural gas and preheated air to give an active reducing gas containing carbon monoxide and hydrogen and then utilising the hot re-formed gas for the reduction of the pyrite cinders.

During 1935 the Mountain Copper Co. operated a unit with a capacity of 1 ton per day which utilises this process, and it is reported that the metallurgical practicability of the method was demonstrated. Cost figures were particularly interesting, for with natural gas costing 15 cents per thousand cubic feet it appears that costs for a plant producing 20 tons of sponge iron per day should range from $16 to $18 per ton of metallic iron produced, and on the basis of 100 tons per day $12 to $14 per ton. Such costs are comparable with local pig-iron and scrap-iron prices ruling in the United States at the present time, and any improvement tending to bring such prices to a more nearly normal level would justify the immediate production of sponge iron as a substitute for these materials under local conditions. An extremely high-grade sponge iron cannot be produced from such impure sources of material as pyrite cinder; the outlet for this grade is therefore limited to competition with the lowest-priced forms of commercial iron.

Gold Recovery by Amalgamation

AMALGAMATION, because of its simplicity and low plant cost, is often selected as a process for the recovery of gold when gold ores are amenable to treatment by this method. Investigations indicate, however, that many more mining companies might profitably recover more gold by amalgamation. Tests have recently been made in America and elsewhere to determine the effect

of a very intimate contact between the mercury and the ore, and of various impurities upon the amount of gold amalgamated. In most cases it was found that the presence of the usual sulphides, oxides, and carbonates of copper and lead have little effect on the loss of mercury incident to fine grinding. Realgar and stibnite, however, caused finely ground mercury to be lost; pyrrhotite and marcasite occasioned more loss than did pyrite.

Two methods were used to disperse finely divided mercury through various ores. In one case the ore and mercury were ground together; in the other case finely dispersed mercury was added to ground ore, the mercury being dispersed by precipitating it from a solution of mercury chloride with metallic zinc and by condensing mercury vapour on cold ore. Plate amalgamation was found to be more effective on samples containing dispersed mercury. By using dispersed mercury the amount of gold amalgamated from one particular ore was increased from 65 to 85 per cent. Using dispersed mercury, however, a difficulty arises in recovering the mercury in a re-usable form. The best amalgamation results seem to have been obtained by grinding the ore sufficiently fine to set free the whole of the gold and then adding the pulp to a slowly revolving drum amalgamator; by this procedure the loss of mercury is small. An example of the efficiency of the process in recovering gold is furnished by a certain ore which yielded 91.8 per cent. of its gold when ground so that only 1.2 per cent. of the material remained on a 200-mesh screen. The loss of mercury in this case was 0.2 to 0.5 lb. per ton of ore treated.

The Spectra of Vanadium

LIGHT from vanadium vapour excited to luminosity in an electric arc and dispersed by a spectrograph is seen to consist of several thousand different monochromatic radiations. These radiations resulting from atomic energy changes are controlled by quantum theory and their interpretation leads to deductions of atomic structure. Available data for 2,000 to 3,000 such spectral lines have recently been compiled and analysed ("Journal of Research," July, 1936). Wave lengths range from ultra-violet (2,000 A) to infra-red (12,000 A), and "the analysis resulted in the identification of 60 doublet, 60 quartet, and 28 sextet terms (atomic energy states) which combine to explain 2,186 observed lines." The principal features of the first spectrum of vanadium are thus disclosed, and all is found to be in excellent agreement with the modern theory of complex spectra. The most intense line of the entire spectrum is a violet one, and this line is extremely sensitive for the detection of vanadium.

Iron and Steel Institute

Autumn Meeting in Düsseldorf

THE autumn meeting of the Iron and Steel Institute will be held in Düsseldorf, at the kind invitation of the Verein deutscher Eisenhüttenleute acting on behalf of the German iron and steel industry. The arrangements for the meeting have been made by an influential reception committee, of which Dr.-Ing. E. h. Friedrich Springorum, president of the Verein deutscher Eisenhüttenleute, is the chairman, and Dr. O. Petersen, director of the Verein, is hon. secretary.

Both sessions will take place in the Eisenhüttenhaus, Ludwig-Knickmannstrasse 27, at 10 a.m. on Monday, September 21, and at 9.15 a.m. on Tuesday, September 22; the second session will be a joint meeting of the Institute with the Verein deutscher Eisenhüttenleute.

The complete list of papers to be presented at the meeting is as follows: "Fourth Report of the Corrosion Committee"; "First Report of the Alloy Steels Research Committee"; "Second Report of the Steel Castings Research Committee"; Dr.-Ing. E. h. Friedrich Springorum, "Technical Developments in German Iron and Steel Production during the last Fifteen Years"; O. Föppl, "The Practical Importance of the Damping Capacity of Metals, especially Steels"; A. Nöll, "Present-Day Problems of the Rolling Mill Industry"; G. Thanheiser, "The Determination of the Gases in Steel by the Hot Extraction Method"; F. Wesemann: "The Firing of Open-Hearth Furnaces in German Steelworks"; H. H. Abram, "The Influence of Vanadium on Nickel-Chromium and Nickel-Chromium-Molybdenum Steels"; W. J. Brooke, H. R. B. Walshaw and A. W. Lee, "Investigations into the Influence of Coke Quality on Blast-Furnace Operations"; E. W. Colbeck, S. W. Craven and W. Murray, "The Determination of Non-Metallic Inclusions in Steel and Iron"; T. P. Colclough, "The Constitution of Blast-Furnace Slags in Relation to the Manufacture of Pig Iron"; A. E. Dobner and S. Skramovsky: "The Reduction of Iron Ores with Solid Carbon"; R. Genders and R. Harrison, "Tantalum-Iron Alloys and Tantalum Steels"; A. L. Norbury and E. Morgan, "The Effect of Non-Metallic Inclusions on the Graphite Size of Grey Cast Iron"; A. M. Portevin and R. Castro, "The Morphology of Inclusions in Siderurigical Products: Part III, Chromium Alloys and Chromium Steels"; G. A. V. Russell and S. S. Smith, "The Roll Problem in Backed-up Mills for Cold Reduction"; T. Swinden and G. R. Bolsover, "Controlled Grain Size in steel."

Andrew Carnegie Research Fund

The Council of the Iron and Steel Institute are prepared to make annually a limited number of grants from the research fund founded by the late Mr. Andrew Carnegie in aid of metallurgical research work. The object of the scheme is not to facilitate ordinary collegiate studies, but to enable students, who have passed through a college curriculum or have been trained in industrial establishments, to conduct researches on problems of practical and scientific importance relating to the metallurgy of iron and steel and allied subjects.

Candidates, who must be under 35 years of age, must apply before September 30, on the special form to be obtained from the Secretary of the Institute. The value of the grant will depend on the nature of the proposed research work, but the maximum amount granted in any one year will, as a rule, not exceed £100.

In considering the allocation of grants, the Council cannot undertake to accept any particular proposal, but will be guided by the nature of the subjects proposed for investigation, giving preference to those which, in their judgment, appear to be of the most practical advantage to the iron and steel and allied industries.

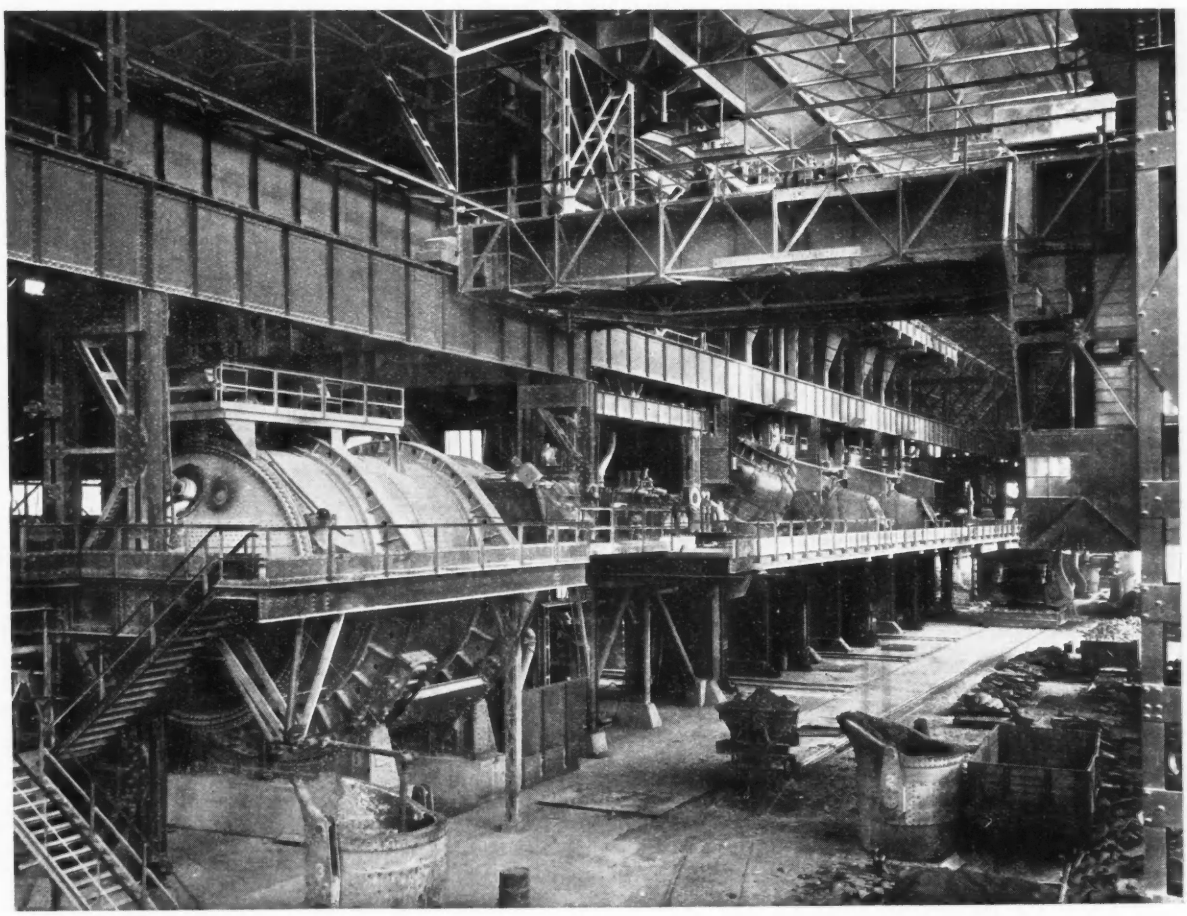
Basic Bessemer Steel Making at Corby

The New Works of Stewarts and Lloyds, Ltd.

THE new iron and steel works of Stewarts and Lloyds, Ltd., at Corby, comprises an ore treating plant specially designed to cope with the peculiar physical and chemical qualities of the ores as well as the irregularities typical of these deposits; a modern blast furnace installation of three units, including the largest in Britain and embodying many new features to enable the operation to be conducted along the most efficient lines and under an entirely new method of smelting not heretofore used; a modern coke and by-product plant, designed to produce a quality of coke most suitable for the production of low silicon pig iron from the Corby ores; a basic bessemer plant of new design, including a large hot metal mixer, a phosphate slag plant and a lime burning plant—the first to use blast furnace gas—and three converters; an installation of blast furnace gas-fired soaking pits with metal recuperators; a heavy blooming mill; blast furnace gas-fired reheating furnaces with double metal recuperators; a strip mill of the continuous type for rolling strip for the tube works, and a continuous narrow strip mill, now under construction.

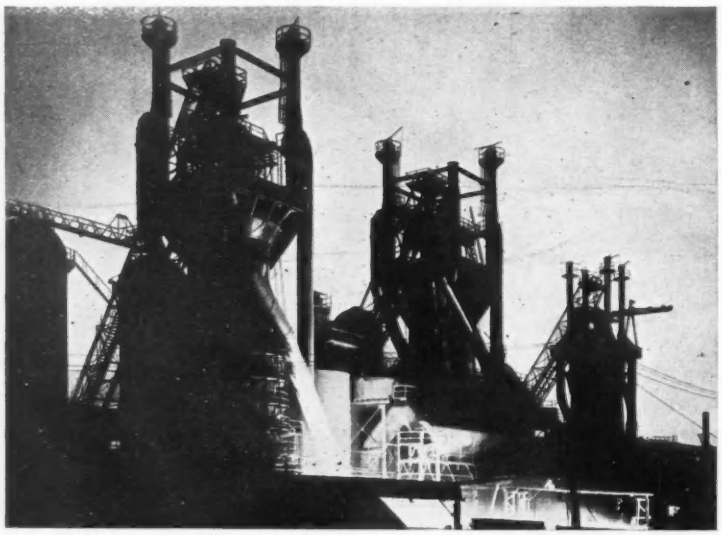
The importance of the new works to the steel industry is that they may bring back to this country the process of basic bessemer steel making. The process of basic bessemer steel making, which was invented by an Englishman, but subsequently fell out of use here, has been developed greatly on the Continent, and most of the cheap steel imported into this country is of that description. Undoubtedly, it owes several of its applications to its cheapness, for it is difficult to vary its quality to suit different requirements as can be done with open hearth steel.

Basic bessemer steel is characterised by its easy rolling, and especially by its good welding properties. It is to the latter quality that it owes its importance in tube making. In fact, several modern tube making processes cannot be carried out with any other material. Whether bessemer steel will yet be produced in this country for the other purposes to which it is suited, it is still too early to say. But there can be no doubt whatever that in making any future plans for the manufacture of bessemer steel in Britain the information obtainable from the technical and economic results achieved by the Corby Works will be of the greatest importance.

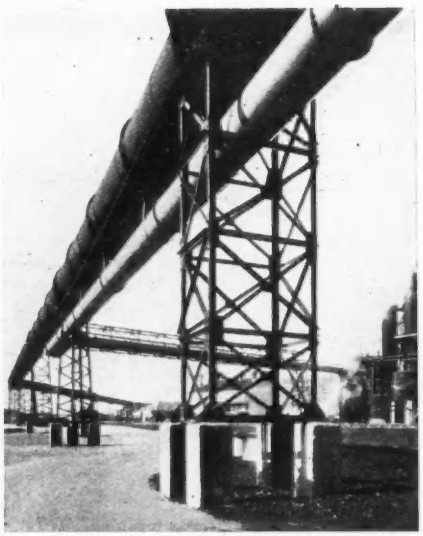


Basic Bessemer Steel Plant, with Hot Metal Mixer, at the Corby Works of Stewarts and Lloyds, Ltd.

In the raising of steam, heating of ingots, and reheating of billets and slabs as well as in the steel works and rolling mill operations, the fuel used is either blast furnace gas or coke oven gas, or a mixture of both. The coke ovens are fired with blast furnace gas, making available the whole of the coke oven gas for other uses within the plant. The use of blast furnace gas, especially in the coke oven silica regenera-



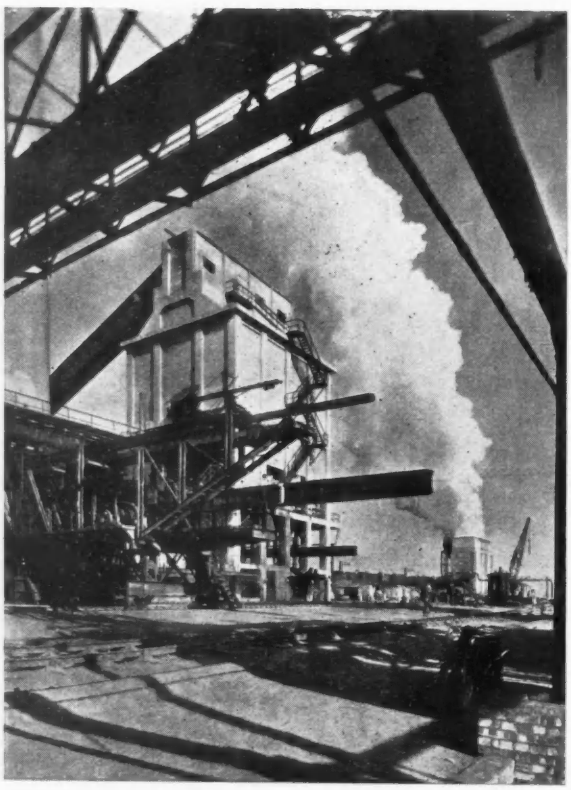
The Corby Blast Furnaces as seen at Night.



Blast Furnace and Coke Oven Gas Distribution Mains.

tors and also in the heating furnace recuperators, made it necessary to clean the gas to a high degree of cleanliness. It has been found that the use of blast furnace gas of high purity is also economical for use in hot blast stoves, boilers, soaking pits and, in fact, every application.

The problem of cleaning the blast furnace gas at Corby



Becker Coke Oven Plant, Coal Bin and Quenching Station.

was a difficult one, since the Northants ores, being carbonates, produce an unusually large amount of very fine dust upon becoming calcined in the upper part of the furnace. A portion of this dust escapes with the blast furnace gas mixed with the usual white fumes formed of combinations of lime, silica, and alumina, and containing, in the case of Northants ores, a considerable amount of potash which is particularly difficult to precipitate in the usual cleaning systems.

The problem was solved at Corby by the application, consecutively, in the cleaning system of five methods, each fulfilling a definite purpose. The first two are carried out in the hot dry state and consist of precipitation by slow motion followed by elimination from the gas current through high tangential velocity; the last three are wet stages consisting of static washing, mechanical washing and electrical precipitation.

Consecutive Hot and Cold Water Washing

Use has been made in the wet cleaning stages of consecutive washing with hot and with cold water, the washing with hot water to ensure breaking down the surface tension between dust and water, and the cold washing to condense the water vapour and to complete the fine cleaning. The gas is delivered at close to atmospheric temperature with a minimum of obsolute moisture and entrained water.

The apparatus used to carry out these cleaning processes are, for the dry stages, large individual dust catchers, one at each furnace, followed by a joint installation of smaller diameter whirlers; for the wet stages, a group of multiple-stage tower washers and disintegrators, followed by an electrostatic precipitation plant.

The whole gas cleaning installation is under pressure from the blast furnace plant created and maintained by the turbo-blowers which furnish the blast to the furnaces at a pressure averaging 15 lb. to the sq. in. The gas pressure at the top of the furnaces averages about 18 in. and the clean gas passes into the distributing system at about 8 in. pressure. A 2,000,000 cu. ft. gas holder maintains the gas pressure at a uniform level, a very important feature in relation to safety as well as efficient control of combustion. The blast furnace gas is distributed throughout the works, the desirable differential pressure as between the various gas mains leading to the different plant units being maintained by automatic control. A clean gas bleeder, also automatically controlled, can keep the holder piston at any desired level. This holder, as well as the coke oven gas holder, is of the waterless type.

By Product Plant

The by-product plant consists of 35 Becker type coke ovens, of the cross-over flue regenerative combination type, arranged in a single battery. The capacity of each oven is approximately 14½ tons of coal, and the plant was designed for an output of 3,500 tons of coke per week. Either blast furnace

gas or coke oven gas can be used for firing, and the gas mains are arranged so that any selected number of ovens can be heated by blast furnace gas, while the remaining ones are heated by coke oven gas. After passing through the screening plant, the furnace coke is conducted to the blast furnaces by means of belt conveyors, and is there distributed by a shuttle conveyor operating above the coke bins. The gases are flushed with liquor and the condensed tar collected. Final tar extraction is by electrical precipitation units in parallel. From a holder of 1,000,000 cu. ft. capacity the gas is distributed to the various plant units. Surplus gas is released through a bleeder automatically controlled.

The by-products plant comprises an ammonia plant and a benzole plant. The first-named is of the indirect recovery type and no liming of the liquor is employed, as the effluent evaporation plant is designed to recover ammonium chloride for use within the works. The benzole plant is designed for recovering a crude spirit, equivalent in quality to a once-run product; a secondary fraction being simultaneously obtained which contains the wash oil and the naphthalene.

Knowles Ovens

There are also four horizontal floor Knowles ovens, designed to produce blast furnace coke, pitch coke and domestic coke from a liquid charge of non-coking coals and tar. The cycle of operation is to produce first pitch or electrode coke from tar alone and then mix the resultant distillates with non-coking coals to produce coke suitable for blast furnace or domestic use. The special feature of the pitch coke is the low ash content, below half per cent., and the feature of the blast furnace and domestic coke is a high rate of combustibility.

The coal handling, washing, blending and crushing plant is designed to handle 5,500 tons of raw coal in 45 working hours. The washer box, fitted with a patent stirrer, is of the type in which the coal and the dirt are stratified by vertical pulsating currents of water.

The Basic Bessemer Plant

Each of the three converters of the basic bessemer plant has a capacity of 25 tons with a maximum of 28 tons, and they are supplied with molten pig iron from a 1,000-ton mixer of special design to conserve heat properly and equalise the variations in the hot metal. This mixer is fired by automatically controlled coke oven gas burners, one at each end, with an auxiliary burner at the spout. The metal is brought to the mixer directly from the blast furnaces in 60-ton ladles. The basic bessemer vessels are blown by two turbo-blowers so designed that the air pressure is maintained at any required figure. Blast furnace gas-fired kilns provide the requisite lime.

The soaking pits operate with straight blast furnace gas or with mixed gases; the proportion of blast furnace and coke oven gas in the mixture is automatically controlled and is variable between wide limits. From the soaking pits the ingots are transferred to a 40-in. reversing blooming mill, and after being rolled to specified dimensions the blooms, slabs and billets pass to up-cutting hot shears for cutting into slabs. Eventually the billets pass into reheating furnaces or into stock.

Non-Metallic Inclusions in Cast Iron

British Cast Iron Research Association Bureau Report

IT is now generally admitted that the presence of minute slag-like particles or non-metallic inclusions in certain metals and alloys effect their properties in a manner which is out of all proportion to their concentrations in the metals, and much attention has been devoted to the study of this phenomenon, particularly in so far as it affects the properties of steels and certain non-ferrous metals. In the case of cast iron, however, no systematic study of this problem had been carried out until quite recently, states E. Morgan, M.Sc., in the course of a review of the literature on "Non-metallic Inclusion in Cast Iron" (Bureau Report No. 152, British Cast Iron Research Association). Nevertheless, some of the results already obtained, both in Germany and from the B.C.I.R.A. investigations, show that the properties of cast irons are also affected very markedly by the presence of certain types of non-metallic inclusions, and the B.C.I.R.A. work suggests, moreover, that all cast metals are affected in a similar way by inclusions, since in all cases the process of solidification is governed by the same fundamental principles.

The examination at high magnification of polished and etched sections of cast irons reveals, in addition to the usual constituents of the structure (graphite, cementite, pearlite, ferrite and phosphide eutectic), minute areas of some other constituents, which appear as more or less perfectly formed crystals of varying colours or just dark specks barely visible under the microscope. These small areas are seen more clearly in the unetched sections and particularly so in the case of white cast iron, since the structure is not broken up by graphite plates as it is in the case of grey irons. The number of these small areas is seen to vary from one iron to another and they are arranged in different ways in the structure. Some have been identified as sulphides, some appear to be oxides or silicates, while some have been supposed to be nitrides, and mixtures of nitrides and carbides.

Since very little is actually known regarding the nature of inclusions present in cast iron it is not possible to describe exactly the way in which inclusions are formed. In certain cases, however, the origin of an inclusion can be traced without any manner of doubt to some part of the furnace refractory, to the ladle or to the mould, small portions of the furnace lining, or the sand from the mould being broken away and washed into the mould by the metal and trapped there. Such inclusions may be quite large and are often the cause of the casting failing under some particular test, such as a pressure test. Apart from being the cause of such failures this type of inclusion is not regarded as having any general influence on the structure and properties of cast iron, since, owing to its size and the way in which it originates in the first place, it is generally confined to some particular part of the casting.

The bulk of the inclusions present in cast irons have originated either in the blast furnace or else in the cupola or other melting furnace. During the manufacture of pig iron in the blast furnace, as also during the subsequent melting of pig iron, large quantities of slaggy material are produced.

Generally speaking, this slag, which consists mainly of silicates, with various metallic oxides, etc., which are held in solution and suspension, is very fluid at the working temperature, and since its specific gravity is much lower than that of molten cast iron it tends to separate quite rapidly from the metal. On the other hand, Stokes' Law tells us that the influence of gravity in causing these suspended particles to rise to the surface decreases as the particle size decreases. Very small particles therefore tend to remain suspended in the molten iron. The extent to which they remain will also depend on their coagulating power, which is again related to particle size, and also to the viscosity of the iron. The melting point of the slag is also important,

since the longer the slaggy suspension remains molten in the iron the greater will be the tendency to coagulate into larger particles and rise to the surface.

Some types of inclusions are probably formed while the metal is cooling, due to the action of dissolved gases which are evolved rapidly as the temperature falls. These gases may be oxidising and react with the elements silicon, manganese and iron to form oxides and silicates. Oxygen and nitrogen from the atmosphere are also factors to be borne in mind in the formation of inclusions. The surface of the metal is oxidised when it is tapped out of the furnace and also when it is poured into the moulds, and the oxides formed may be trapped in the metal. This is particularly noticeable when the iron contains some aluminium or chromium.

Effect of Dissolved Oxygen

A good deal of study has been given to the effect of dissolved oxygen on the properties of cast irons. In 1914, J. E. Johnson ("Trans. Amer. Inst. Min. Met. Eng.," 1914, *50*, 344) ascribed differences in the properties of coke and charcoal pig irons to differences in their oxygen contents. He melted coke irons with varying amounts of a pig iron which was supposed to be highly oxidised since it had been made in a very cold-working blast-furnace. It was found that as the proportion of this "oxidised" iron in the mixture increased so the mechanical strength was increased.

Whether the effect of oxygen on cast iron is beneficial or not it has been shown that cast iron melted in the absence of air or oxygen has a different structure from that melted in the presence of air. For example, Hanson ("Journ. Iron Steel Inst.," 1927, *116*, 129) found that when iron-carbon-silicon alloys made synthetically from pure materials were melted *in vacuo*, the structures obtained were of the type which we now call the supercooled structure, consisting of a mixture of finely divided graphite in ferrite. The same samples remelted in air for the purpose of taking cooling curves produced the structures corresponding to those of normal cast iron, consisting of coarse flakes in pearlite and ferrite.

Graphite Inclusions

Although it has been stated that graphite flakes are not regarded as inclusions in the same terms as oxides, silicates, etc., it was thought for some time that when cast iron is melted in the cupola very minute particles of undissolved graphite remained in the melt and that the presence of this graphite residue had an important function with regard to the structure and properties of cast iron. In consequence of this it was stated that the graphite structure of the pig iron, and hence its fracture, was the predominating factor in determining the properties of the cast iron, since the coarser the flakes in the pig the greater the amount of undissolved graphite that would remain in the molten iron and therefore the greater the nucleating effect, since the residue was supposed to act as nuclei for crystallisation. Many of the anomalies observed when melting cast irons could be explained on this basis.

In 1933 Von Keil and H. Legat published some results ("Die Giesserei," 1933, *20*, 214) in which they claimed that the stable graphite solidification, by which they mean the normal coarse flake graphite solidification, is promoted by the presence in the molten iron of iron-silicate inclusions of sub-microscopic dimensions. Their results were based on experiments carried out on iron-carbon-silicon melts, iron-carbon-nickel melts and aluminium-deoxidised melts. It was found that when the melts contained no silicon, or when there was no possibility of the formation of any iron-silicate, these melts solidified to produce the supercooled graphite structure. When, however, the melts were carried out under conditions which gave rise to the formation of silicates then in every case the normal coarse graphite structure was obtained. Later, in 1934, Von Kiel and his collaborators ("Archiv f. Eisenhüttenwesen," 1934, *7*, 579) stated quite definitely that neither the graphite nuclei nor the total oxygen content determines whether cast iron will solidify with coarse or fine graphite structures, but rather the presence or absence in the molten metal of iron silicate slime, *i.e.*, iron silicate particles so fine as not to be visible under the microscope.

It was claimed by Colbeck and Evans ("Foundry Trade Journ.," October 5, 1933, p. 191) that treatment of molten cast iron by means of soda ash, besides removing some of the sulphur present, has the effect of removing inclusions from the melt partly by direct fluxing and partly due to the action of particles of molten sodium carbonate of attaching themselves to silicate inclusions and thereby increasing the size of the inclusion. For instance, a basic pig iron before treatment with sodium carbonate contained 0.104 per cent. SiO_2. Treatment with 1 per cent. Na_2CO_3 reduced the silicate content to 0.061 per cent. Diminishing the silicate inclusion content has the effect of refining the graphite structure.

Silicate Inclusions

In this Bureau Report No. 152 the B.C.I.R.A. have made an attempt to summarise the work that is relevant to the subject of non-metallic inclusions in cast iron. The most important work relates to the influence of silicate inclusions. Whether the responsible inclusions are so small as to be sub-microscopic in dimension or whether they are much larger and are revealed by the microscope is a matter which must remain open since there is no means available at present for isolating and measuring very small inclusions. The laws of crystallisation certainly require that the inoculating particles should be exceedingly small so that it is quite likely that the silicates responsible are indeed sub-microscopic and even the presence of visible inclusions does not preclude this possibility.

The silicate slime theory, as propounded by Von Keil and his collaborators, may be said to fit in exceedingly well with the facts emerging from the particular experiments on which this theory is based, but its main drawback is that it requires for the purpose of producing an iron containing supercooled graphite, a melt which is absolutely free from silicates, and it is very unlikely in the ordinary production of castings that the conditions of melting are other than those which produce silicates. Nevertheless there are numerous cases when supercooled graphite can be seen in large quantities sometimes extending over the whole section of the casting and sometimes confined to certain areas in the castings and sometimes even in a pig iron. Under these conditions, and they are fairly common, the silicate slag theory breaks down.

The view held by the B.C.I.R.A., as a result of extensive experiments carried out on the influence of inclusions, is that although silicate inclusions are responsible for the coarse graphite structure their inoculating power can be removed without actually removing the inclusions from the melt, and the process is one of partially liquefying the inclusion so that it loses its crystal property.

Alloys and Aircraft

Metallurgists' Flight to Paris

So many members of the Institute of Metals—including the president, Mr. W. R. Barclay—desire to fly to France for the Institute's annual conference in Paris on September 14-18, that Imperial Airways, Ltd., has arranged to run one of its largest machines specially for the party. This will be one of the very few occasions on which members of a British scientific society have proceeded *en masse* to a foreign meeting by air. As metallurgists they will be particularly interested in the technical details of the aircraft used for their journey.

Modern flying has been made possible largely as a result of the development of light alloys of aluminium and magnesium, and of special steels, by British metallurgists. At the Paris meeting the latest researches on alloys will be discussed before a gathering of experts from all parts of the world.

Metallurgical Section

October 3, 1936

Improved Methods for Obtaining Magnesium Metal

MAGNESIUM metal is usually produced by the electrolysis of anhydrous magnesium chloride, using a flux of molten salts to carry the electrolyte. The main disadvantage of this method lays in the necessity for a temperature of about 700° C. to ensure liquidity, and at that temperature there is also some loss of the reduced metal by vaporisation. In addition it is necessary to use perfectly anhydrous magnesium chloride, which is also free from oxides and alkali metals. Attempts to produce magnesium from natural magnesium compounds by reduction with carbon have failed owing to the complete reversibility of the reducing reaction; at ordinary pressures equilibrium is on the metal-forming side only above 2,000° C., when the metal is in the vapour phase, yielding—when condensed—a mixture of metallic dust, oxide in considerable quantity, and soot.

In an improved process of Austrian origin the metal is extracted in two stages. Magnesium oxide, obtained by calcining magnesite or dolomite, is reduced by carbon in an electric furnace at a temperature of about 2,000° C., which is well above the boiling point of magnesium metal. The reduced magnesium leaving the furnace in vapour form along with the carbon gases is then filtered from accompanying dust and rapidly cooled to 200° C. In the second stage of the process this cooled product, which is a mixture of magnesium metal, oxide dust and soot, is conducted to the hot zone of an electric furnace and heated to 800-1,000° C. in partial vacuum (20-100 mm. mercury) in the presence of hydrogen or methane. Here the magnesium is vaporised and, being brought into contact with a cooling surface, its temperature is lowered to the liquefying but not to the solidifying point, and the liquefied metal in the form of drops falls into a bath of hydrocarbon oil of high boiling point. This oil causes the coalescence of the drops into granules 10-20 mm. diameter and at the same time separates any dust, so that the metal is isolated at a purity of about 99.97 per cent. Metal and dust, moreover, can be easily and independently separated from the oil. Aluminium can be used as the reducing agent instead of carbon, thereby eliminating the formation of gases so that only magnesium vapour escapes from the furnace. The new process is favoured because of the high purity of the resulting magnesium metal.

Lead and Nickel in Italy

LEAD ore production of Italy increased from 33,000 tons in 1934 to 37,000 in 1935, whilst metal production dropped from 48,000 to 40,000 tons. The consumption of lead for 1935, however, was 65,000 tons. It was the heavy duty of 170 lire per ton, applied to lead ores late in 1934, which was largely responsible for the decreased production; for instance, the principal importers, the Societa' di Pertusola, who are the owners of the lead smelter at La Spezia, suspended operations early in 1935, as they did not wish to pay this duty, and, unfortunately, their own lead mines in Sardinia could supply only a small part of their requirements. Increased output from the mines and renewed imports, however, permitted operation of the smelter during the last six months of 1935. The reduced production from other smelters was compensated in part by an increase from the new smelter of the Montecatini group at San Gavino, Sardinia, built in 1933 to treat ore from the Montevecchio mine which was formerly exported. It is reported that 160,000 tons of lead were produced at this plant, which is experimenting with a new electrolytic refining method. Nevertheless, although the lead smelter capacity in Italy is now sufficient to satisfy normal national demands for metallic lead, the mines are not yet capable of supplying the required tonnage of ore, thus indicating a possible shortage of about 20,000 tons which will have to be imported.

Italy depends entirely on imports for nickel requirements, which averaged 1,200 metric tons for the years 1930-34. Normal requirements are now believed to be about 2,000 tons, but because of the disturbed political situation imports are estimated to have been 2,800 metric tons in 1935, against 1,950 tons in 1934, in spite of the fact that the Government encouraged substitution of other metals for nickel whenever possible. While there are no productive mines and no smelter for treatment of nickel ores, Italy has deposits of nickel in Sardinia and in Piedmont. The former have not been worked since 1925; the latter not since 1880. Survey work, however, is now being done in the Piedmont section with Government assistance and it is possible that a small experimental smelter may be built.

Future of the Steel Industry

THE British Iron and Steel Federation are now making preparations to submit to the Import Duties Advisory Committee their views on the future development of the iron and steel industry. It was following the discussion in the House of Commons about two months ago, on the proposal to establish steel works at Jarrow, that Mr. Walter Runciman, President of the Board of Trade, first announced that the Import Duties Advisory Committee were to examine and report upon the position of the iron and steel industry with regard to its development. It is understood that the industry's future throughout the whole of the country is concerned, and that the Committee is seeking information about ability to overcome any shortage of iron and steel should the present heavy demand continue. Information has already been supplied by the majority of firms to the Committee regarding cost of production, inclusive of raw materials, administration and sales services, and these costs will be collated

by the Committee when considering the price policy of the Federation.

A rather important direction in which further steps will probably be taken by the Federation, and in which the Import Duties Advisory Committee are particularly interested, relates to expansion and development of productive capacity. It is obviously desirable under any scheme of national organisation that development should be co-ordinated and that expansion of production by individual firms should conform with national considerations and a considered policy by the Federation. The majority of undertakings have, during the past two years, taken measures which will lead to an enlargement of output, either by improving the efficiency of their existing plant or the construction of new producing units. In many cases both courses have been followed, so that the national production of steel is now in the neighbourhood of 11,000,000 tons per year. With the present abnormal demand for steel there is an immediate outlet for the whole of this large production, but although there is reason to anticipate a progressive development in the use of steel it seems very unlikely that the present exceptional production pressure will continue indefinitely. In consequence, it is well recognised that the future development of the industry must be carried out on ordered lines, so that a proper balance between different sections is reached and maintained and serious problems are avoided in the future.

European Zinc Production

ZINC is the only major non-ferrous metal that Germany can produce in sufficient quantity for domestic requirements, and complete independence of zinc imports may be achieved within a year or two. The production of zinc ores (usually associated with lead ores) amounted to 2,355,000 metric tons in 1935, but only 1,555,000 in 1934. Plans are progressing to increase zinc smelter capacity (at present about 140,000 tons) by increasing the capacity of the new electrolytic plant at Magdeburg from 40,000 to 60,000 tons, and by completing the new plant at Oker (which uses the New Jersey Zinc Co. process) at an annual capacity of 40,000 tons. Other important developments include a new flotation plant at Meggen, which will recover 5,000 tons of zinc blend annually from pyrite; new rotating furnaces at Meggen that recover zinc as oxide from pyrite cinder containing 10 per cent. zinc; and the discovery of a rich lead-zinc deposit at the Augusta Viktoria coal mine in the Ruhr, for which a concentrating plant is being planned. Considerable progress has also been made in the substitution of zinc alloys for copper, nickel, and other imported metals.

In Italy, the consumption of zinc increased from 31,000 metric tons in 1934 to 34,000 tons in 1935. The new electrolytic zinc plant at Porto Marghera to be completed this year will produce 1,000 tons of metallic zinc per month. Italy will then be not only independent of zinc imports, but may become an exporter of zinc metal as well as zinc ore.

In Poland, on the other hand, zinc is produced primarily for export. About three-fourths of the output is sent to Austria, Czechoslovakia, Germany, Sweden and certain overseas markets. Exports in 1935 declined 9 per cent. from the preceding year and 54 per cent. from the peak year of 1930, when they aggregated 140,000 metric tons. The reasons for this lack of demand for Polish zinc are five. In the first place Germany has not only curtailed foreign purchases, but has also diverted German zinc ore formerly smelted in Poland to the new electrolytic zinc plant at Magdeburg. Secondly, Belgium has increased its annual production 114 per cent. over that of 1930, whereas Poland has only 49 per cent. of its output of that year. Thirdly, Great Britain has restricted its foreign imports of zinc by imposing prohibitive duties and promoting Canadian and Australian production. In the fourth place, the Soviet Union is expanding its domestic production and its Polish imports are now negligible, and lastly, Czechoslovakia's imports from Poland, although steady, are only half of their former tonnage.

Treatment of Cupriferous Gold Ore

THE cyanidation of gold ore containing a small amount of copper is being successfully carried out by a mining company in South Africa, and the method adopted is of particular interest to metallurgists. The plant treats the ore from several mines, the average composite assay of which is gold 5 dwt. per ton, and copper 0.09 per cent. Interest is principally centred in the method of precipitation with recovery of the zinc. The solution strength in the cyanide plant is maintained at 0.045 per cent. sodium cyanide and 0.01 per cent. lime.

The gold-bearing solution from sand and slime plant is collected in a common tank before passing to the filiform zinc precipitating boxes. These boxes are dressed half-monthly and fresh zinc is then added. The new zinc receives a medium coating of lead nitrate and a little lead nitrate solution is daily added to each zinc compartment; this appears to be a valuable aid in counteracting bad precipitation. In strong cyanide solutions copper interferes very little with the normal working of the boxes, but should the free cyanide content in the solutions become low, the zinc readily becomes coated with an adherent film of copper, and gold precipitation troubles follow. Approximately 50 lb. of copper is precipitated daily upon the zinc; the zinc consumption amounts to 0.36 lb. per ton of ore milled; total cyanide consumption is 2.5 lb. (100 per cent. NaCN) per ton, and lime consumption is 12 lb. (65 per cent. available CaO) per ton.

The clean-up takes place once a month when the zinc and fines are treated with sulphuric acid. The zinc sulphate solution, after being pumped through the filter press, is stored in a cement tank until required for timber preservation. Sulphuric acid and sodium nitrate are added to dissolve the copper, and sulphuric acid and nitric acid are used for "finishing off." The gold slime is allowed to settle overnight and the copper liquor is syphoned off into boxes similar to the zinc boxes, but filled with old mill screens, empty cyanide drums, etc. Copper and silver are thereby precipitated upon the scrap iron from which the slime and scalings are collected and sold. When acid treating for copper, the silver does not go into solution until all the copper has dissolved, hence the absence of silver in solution is a sure indication that undissolved copper still remains. This fact is made use of as a guide to determine the point when the nitric acid has exhausted the copper. The cement-copper from the scrap-iron boxes is water washed and air dried, and then ball-milled until it passes 200-mesh screening.

Electrodeposited Coatings as Corrosion Preventives

Dr. S. Wernick Reviews the Present Trend of Development

IT is perhaps not fully appreciated by those outside the electrodeposition industry how remarkably diverse are the applications of electrodeposited coatings at present, said Dr. S. Wernick in a contribution to the discussion on "Electrodeposition," which formed a feature of the Chemistry Section at the meeting of the British Association for the Advancement of Science, at Blackpool, on September 11. Electrodeposition is now commonly practised as one of the series of manufacturing operations involved in the production of a very considerable proportion of the metal articles of the most varied kind which are produced to-day.

The function of the electrodeposit is mainly twofold, namely, decorative and protective. Other valuable properties may be imparted to the surface as a result of electrodeposition, of which one of the most important, as for example, in the case of nickel and chromium plating, is added hardness. While the decorative aspect of electrodeposition is an important one since an attractive finish has been found to possess considerable commercial value, it is the protection which an electrodeposit can provide which determines the serviceability and length of useful life of the article so finished. Certain electrodeposits have been found to be outstandingly valuable as corrosion preventives, and in this paper it is proposed to deal with typical deposits of this class.

Economic Aspects of Corrosion

The corrosion of metals is a matter which affects us closely since the loss entailed as a result of corrosion constitutes one of the most serious drains on the world's resources. The corrosion of the ferrous metals alone—iron and steel—is taking place all over the globe at this moment at a rate which means a loss roughly equivalent to £2,000,000 per day. This colossal waste is proceeding without a moment's cessation in every country throughout the world.

Mankind fights corrosion in many ways and in so doing, incidentally, spends something like £150,000,000 annually in the task. These may be considered to be very conservative figures. Most of these preventive methods take the form of surface protective coatings, and both organic and inorganic materials are used. The former comprise paints, enamels, varnishes and lacquers; and the latter, mainly metal coatings. Two of the most widely used metal coatings, which the public encounters at every turn, are produced by galvanising and hot tinning. These coatings are obtained by immersion in the comparatively low melting-point metals of which they consist—tin and zinc respectively.

Advantages of Electrodeposited Coatings

During the present century, electrodeposited or electroplated coatings, which are produced by electrolytic means, have been used in increasing quantity for protective purposes. In the protection of iron and steel which represent the most corrodible of common metals, zinc and cadmium plating in particular have been developed and utilised on a rapidly increasing scale commercially. One of the most important advantages of electrodeposited coatings is the certainty of control of thickness which this method offers—a very important matter from both the cost point of view and also the accuracy with which it is possible to work to specification and ensure the production of metal finishes—as they are called—of adequate corrosion resistant quality.

As instancing the control of thickness which is possible, electrodeposited metals have been applied which are a fraction of a millionth of an inch thick and which are therefore built up of an almost countable number of atoms. When separated bodily from the basis metal, such thin deposits are truly transparent, and may be obtained free from pores and of practically perfect quality. Thin sheets of gold obtained in this manner are so transparent that it is possible to read print clearly through six successive layers of the metal separated by air gaps. A practical demonstration of this almost unbelievable scientific phenomenon was on view on the occasion of the Faraday Centenary Celebrations in London in 1931.

At the other end of the scale are the thick deposits which are built up in the solution, atom by atom, until they attain a thickness some million times greater than the very thin deposits just referred to. When we consider that it is possible to regulate this thickness to almost any intermediate point between these two extremes, it is apparent that the control attainable by electrolytic methods of coating surfaces is exceedingly fine.

Practically any metal deposit which is itself able to resist to a considerable degree the corrosive influences of the atmosphere may be utilised as a protective coating for the ferrous metals. The majority, however, require to be plated comparatively heavily in order to ensure that surface wear may not rapidly expose the underlying basis metal, which will then corrode locally. The metal deposits may, however, be divided into two classes, according to whether they are electro-negative or electro-positive to iron. Those which are electro-negative are the most suitable corrosion preventives. Zinc and cadmium to which reference has already been made are the most useful of the electro-negative deposits and are therefore widely used for this purpose.

Electrochemical Protection

The mechanism underlying the action of zinc and cadmium as rust preventives is the same and is of some interest. The effect is not merely mechanical arising from the zinc and cadmium plating screening the iron below from the atmosphere. Due to the position of zinc and cadmium in the Electrochemical Series of elements, the basis metal is protected even where the deposited metal is imperfect or discontinuous, as at scratches or pores in the surface where the iron or steel is in direct contact with the surrounding atmosphere. At such points, conditions analogous to those obtaining in a simple battery are produced. A simple electrochemical system is set up through the contact of the basis metal and the deposited metal with a mild electrolyte represented by the moisture in the atmosphere (the latter contains a small percentage of carbonic acid which is invariably present in greater or less amount and thus provides an electrolyte of fair conductivity). The two metals and the electrolyte thus constitute a cell, in which the more anodic or less noble metal will "enter solution" or, in other words, corrode. Zinc and cadmium are both anodic to iron and hence corrode preferentially or "sacrificially"; as a result, they protect the latter. This is the basis of the protective action not merely of the electrodeposited coating, but also those produced by other means, *e.g.*, galvanising.

Zinc and Cadmium Plating

The difference of potential between iron and zinc is much higher than that between iron and cadmium and hence the sacrificial electrochemical action is definitely greater in the case of zinc than with cadmium. Relatively thinner deposits of cadmium are therefore ordinarily employed for industrial purposes in this country, *e.g.*, while a thickness of about 0.0005 inch might be specified for zinc plating, about 0.0003 inch is a typical average deposit for cadmium plating.

Since cadmium is considerably more mostly than zinc, no economic advantage accrues through the use of the thinner cadmium deposit. The relative advantages of zinc and cadmium plating industrially have been fully explored, and a field of usefulness has resulted for each type of protective in

consequence. Thus, it has been proved as a result of a number of researches that cadmium is somewhat superior to zinc as a protective for ferrous material under relatively mild conditions, *e.g.*, interiors and rural atmospheres, while zinc plating is better when protection is required in exposed or very wet conditions.

Zinc-cadmium alloys have been deposited in recent years and are now being used to a certain extent in industry. They are roughly intermediate in their properties between those of of the constituent metals and they have the advantage of cheapness over cadmium deposits while retaining some of the qualities of the latter. A difficulty which arises is the maintenance of a deposit of uniform composition since the percentage of the constituent metals in the deposit varies with the operating conditions. The production of electrodeposits of zinc and cadmium of good quality is dependent on the use of an electrolyte of balanced composition, facilitating the maintenance of uniform conditions. The electrolyte almost invariably in use in the case of cadmium is an alkali double cyanide, while both acid sulphate and cyanide solutions are used in zinc plating.

Control of Operating Conditions

In the case of the cyanide solutions, the conditions which require to be controlled are the concentration of the constituents of the electrolyte (metal, free cyanide and caustic alkali), the current density, the temperature of the solution and the anode/cathode area ratio. Equal rates of solution of the anode and deposition at the cathode are also obviously necessary to maintain the metal content of the electrolyte. The optimum operating conditions have been determined and any marked diversion from these results in an appreciable change in the structure of the deposit, which in turn affects the corrosion resisting properties of the coating. The structure of the deposit may vary from one of extreme fineness to one which is so coarse that the individual crystals constituting the deposit are readily perceptible. The most desirable type of deposit is one which has a very fine structure (apparently non-crystalline to the eye), since this type of deposit provides the maximum degree of protection to the basis metal.

Another important factor is the uniformity of the deposit over the surface of the article plated. This is bound up with the "throwing power" of the electrolyte employed (already referred to in the previous paper) which is that characteristic of the bath which determines the degree of variation of the deposited metal over the cathode area. In the case of zinc plating the cyanide solution has a far better throwing power than the acid bath, so that articles of complex shape should preferably be plated in this type of bath to ensure adequate covering of those parts which are more remote from the anode, such as re-entrant angles, channelled or tubular parts, etc.

The industrial application of protective deposits is considerable. Small engineering parts constructed of steel are almost invariably protected by electrodeposited zinc and cadmium. An advantage of these deposits is that they can be finely controlled in respect of the thickness applied, so that fine tolerance limits in dimensions may be safely worked to. The deposits are used in the finishing of parts required in electrical engineering, wireless, aircraft work, building fittings, household appliance of all kinds, and in particular as a protective to resist tropical and marine climates.

Anodic Oxidation of Aluminium

This is a very important electrochemical application which cannot perhaps be strictly termed "electrodeposition" since this is not so much a depositing process as the transformation of the metal surface into its oxide. Aluminium belongs to that class of metals which owe their comparative immunity from corrosion to the presence of a natural thin layer of oxide on the surface. The process of anodic oxidation of aluminium is, so to speak, an improvement on nature in that this layer is artificially very considerably thickened by making the aluminium the anode in a suitable electrolytic circuit.

The first successful anodic process was the result of the work of two British chemists, Bengough and Stuart, who in 1923 published the results of work carried out with a weak chromic acid electrolyte (3 per cent.) utilising carbon cathodes and an applied voltage stepped up periodically to some 60 volts over a period of one hour. A full description of the process was given by Bengough and Sutton before this Association in 1926. Since then, other processes using such electrolytes as sulphuric and oxalic acid have been developed, in which uniform or non-varying voltage conditions are employed and shorter times required for producing the requisite oxide film.

Properties of the Oxide Film

The oxide film possesses remarkable properties apart from its unique protective qualities. Thus, it is extremely hard, as one might expect an oxide of aluminium to be, and therefore highly resistant to wear and practically every form of abrasion. The author has subjected an oxide film produced by a process utilising sulphuric acid electrolyte to the wear occasioned by a rotating calico mop 12 inch in diameter the speed of which was 1,800 r.p.m. (lineal speed exceeding 5,000 ft. per minute) and found that the film withstands such abnormal conditions remarkably well. The film is also an electrical insulator and has been found to resist comparatively high voltages of the order of 1,000 volts under special conditions. Hence an anodised piece of aluminium comprises an excellent conducting core covered with a well insulated layer of oxide.

The heat radiating properties of the oxide represent a marked improvement on the original surface. Its light reflecting properties are also valuable in that the blue cast of aluminium is replaced by the whiter oxide while the even etching of the surface resulting from the electrolytic action in anodising provides a surface which results in a high degree of diffusion of the reflected light. An even, uniform reflection is achieved which has been utilised successfully for such special applications as searchlight reflectors and floodlight equipment. The anodic finish thus provides good reflectivity allied to excellent corrosion resistance of the reflecting surface to outdoor conditions.

Its most interesting quality is its mordanting property, as a result of which it readily adsorbs dyes to form a lake. This property has been developed so that it is now possible to obtain aluminium which is not merely highly protected but attractively coloured in almost any desired shade. Special colours have been developed which very successfully resist the effects of practically any specified service conditions. Coloured finishes on aluminium can now be obtained which will resist atmospheric conditions, sunlight, heat, rain, various chemicals, etc. The oxide layer which is highly absorbent when first produced may be impregnated with greases to render it more resistant still, this method being successfully utilised to achieve corrosion resistance of a very high order.

Applications of Anodised Aluminium

The rate of growth of the oxide film during the course of electrolysis is not uninteresting. The thickness of the film increases with time of electrolysis, but this action is not continuous since, simultaneously with the building up of the film, progressive chemical attack of the outer layer of the film is also taking place. There is thus an upper limit to the thickness which can be achieved while at the same time the physical properties of the film are affected by this chemical action. An optimum thickness has been determined which provides the best corrosion resistance for the basis metal.

Anodised aluminium is being used in increasing quantity, the applications being extraordinarily diverse owing to the fact that there is a considerable and growing demand for light metals which possess high corrosion resistance allied with decorative value. Aircraft, marine parts, and architectural fitments which are exposed to severe corroding conditions, are instances of "protective" applications.

The Future of Electrodeposition

Prospects for a New Range of Metals

MORE precise control of the plating process is likely to lead to further improvements in the quality and reliability of electrodeposited coatings and an expansion of the range and scale of their application, said Dr. H J. T. Ellingham, A.R.C.S., in another contribution to the discussion on " Electrodeposition " at the British Association meeting at Blackpool.

Of about thirty metals known to be capable of electrodeposition from aqueous solutions fourteen may be said to come within the range of present-day plating practice. Of about forty other metals—which probably cannot be electrodeposited from aqueous solutions—many are actually produced commercially by electrolysis of their molten salts, but this generally yields the metal also in the molten state. Deposits of these metals suitable for plating purposes may be obtainable, however, from solutions of their salts in solvents other than water, and electrolysis of such non-aqueous solutions for the production of coatings of metals such as aluminium, magnesium, beryllium and tantalum—as well as of tungsten and molybdenum, which may be obtainable also from aqueous solutions—has been the subject of several recent investigations.

Coatings of Manganese

Coatings of tungsten, molybdenum, manganese, iridium, aluminium and beryllium are among those which would seem likely to find useful applications when satisfactory processes for their deposition have been worked out. According to a recent report the electrodeposition of manganese in the form of bright, coherent coatings from aqueous sulphate solutions of carefully controlled *p*H value is now being undertaken for the commercial extraction of the metal from its ores.

No metal is so rare that the possibility of its commercial electrodeposition can be definitely ruled out. Very little metal is required to produce a coating a few hundred thousandths of an inch thick, and if some rare and expensive metal is found to serve a particular purpose better than any other it may be advantageous to use it. Moreover, some metals whose properties render them unsuitable for any of the purposes for which electrodeposits are now employed—decoration, protection against corrosion, tarnish, wear, etc.—may in virtue of their other properties prove valuable for entirely different purposes, some of which may be entirely beyond our present anticipation. The number of metals which may ultimately be electroplated is, in fact limited only by the number known.

Simultaneous Deposition of Two Metals

By the simultaneous electrodeposition of two (or more) metals, alloys of almost any range of composition may be deposited, and since the properties of such alloys are by no means necessarily the mean of those of the constituent metals, but may actually be very different from the latter, the range of possible properties—and hence of possible applications—is here quite unlimited. Although the co-deposition of copper and zinc (brass plating) has long been practised, systematic investigation of the general conditions involved in alloy deposition is still in an early stage. Recent work on the simultaneous deposition of tin and copper led almost at once, however, to commercial application of the resulting "bronze" deposit as an undercoat for chromium plate. Reference to zinc-cadmium deposits has already been made.

For the co-deposition of metals which are widely separated in the electrochemical series the use of a complex salt of at least one of the metals becomes necessary, and it may well be that the immense amount of research work which has been done in recent years on the preparation, properties and molecular constitution of such salts—work which at present is mainly of theoretical interest—will prove to be of great importance in the elaboration of such processes. Moreover, in the practice of alloy deposition control of bath composition and conditions of electrolysis is of very special importance, and the lessons learned in the deposition of single metals will need to be more precisely applied and, no doubt, greatly extended in order to achieve success in this more exacting field.

New Methods and Processes

Apart from the development of these new types of electrodeposited coating, the range or application of deposits already used in present-day practice is also likely to be greatly extended. The introduction of new methods and processes in other industries continually opens up new possibilities. Thus, the fact that in some modern tin plate mills the steel sheet is finally cold rolled in the form of a continuous strip renders it easily amenable to electrolytic pickling treatment, since it can be passed continuously through a pickling bath. Moreover it can then be passed similarly through a plating bath, thus rendering it possible to apply the tin coating by electrodeposition instead of, as hitherto, by dipping in molten tin. This process, for which a number of advantages are claimed, is already being brought towards large-scale operation. Coatings of other metals, such as zinc or copper, may, of course, be similarly deposited on the steel strip.

Although the actual fabrication of objects of special shapes by direct electrodeposition is based on old-established principles, and such " electroforming " processes have in fact grown up alongside true electroplating processes, commercial application to the manufacture of metal tubing and sheet is comparatively recent. By electrodepositing a thick, non-adherent coating of metal on a mandrel rotating in a plating bath, seamless tubing of copper and iron is being produced. Cylindrical shells of metal produced in this way may be slit up and opened out to form metal sheet of controlled physical structure and chemical purity. Thus, copper sheet is being manufactured in this way with mechanical properties superior to those of ordinary rolled sheet, especially in regard to behaviour under cold working, *e.g.*, in making deep pressings. Moreover, by successive deposition of two metals, *e.g.*, copper and nickel, bi-metallic sheet may be produced. Developments in this field are likely to simplify a number of industrial operations.

Competition from Other Coatings

In considering the future of the electrodeposition of metals it will be realised that each new development will have to meet competition from other types of coating and other types of surface treatment which will be developing simultaneously, and one of the chief lessons to be learned from past experience is that the continued progress of electroplating practice is greatly dependent on the maintenance of close co-operation between the plating shop and the research laboratory. Nobody can foretell what kind of new advances in pure chemistry will give the key to the next important developments in electroplating, and it is most important therefore that the practical man shall keep in touch with progress in various branches of the science upon which his industry depends. It is in the nature of things that the most striking advances in science and in scientific industries are those which are the least predictable. Indeed, anything which is predictable is already on the way to becoming commonplace! It is safe to say, therefore, that the really startling future developments in electroplating will not be those to which I have referred, but others which are so novel that they are hardly conceivable in the basis of our present knowledge and experience.

Some Recent Metallurgical Patents

Refining Lead

Lead is refined in a rotary tube furnace which may be heated, *e.g.*, by coal or oil, at one end, the combustion gases which pass through the tube effecting oxidation of the surface of the lead. The lead oxide so formed passes under the metal bath and effects oxidation of metal impurities with the liberation of lead. The oxides obtained may be subsequently worked up into alloys by reduction with carbon. (See Specification No. 442,696, of L. Gutlohn.)

Refining Metals and Alloys

A powder for treating molten metals, particularly lead or tin, or lead-tin and lead-tin-antimony alloys such as are used in type and stereotype founding, comprises by volume 20 to 30 per cent. of sodium chloride, 20 to 25 per cent. of ammonium chloride, and carbon, preferably wood charcoal, with or without starch, nitre, sulphur, and rosin. Preferably the proportion of carbon is 25 to 40 per cent. and the proportions of sodium chloride and ammonium chloride are about equal. (See Specification No. 441,033, of L. M. E. Dent and L. F. Chapman.)

Iron Chromium Alloys

Iron-chromium alloys containing 50 to 72 per cent. of chromium, 1 to 5 per cent. of carbon, 0.5 to 15 per cent. of nitrogen and the balance iron are prepared by reducing chrome ore with a carbonaceous reducing agent in the presence of oxygen-free nitrogen or ammonia gas. The gas may be under pressure and may be passed into the ore during the reduction. When the chrome ore and reducing agent are melted down in a suitable furnace, *e.g.*, an electric furnace having carbon electrodes to form a molten slag containing the oxides of iron and chromium which are then reduced, the gas is bubbled through the slag during the reduction of the oxides contained therein. (See Specification No. 443,891, of Alloy Research Corporation.)

Refining Cadmium

A flux for use in melting and dealing with molten cadmium and its alloys comprises cadmium chloride and/or bromide and one or more alkali salts selected from the group comprising the chlorides and bromides of lithium, potassium and sodium. In use the flux may be regenerated by adding ammonium chloride and/or bromide In an example a flux contains 58 per cent. of cadmium chloride, 22 per cent. of potassium chloride, and 20 per cent. of sodium chloride. The flux may be prepared by fusing one or more of the chlorides or bromides of lithium potassium or sodium upon a cadmium containing bath and adding a corresponding ammonium salt in quantities sufficient to generate in situ in the flux the corresponding cadmium salt. (See Specification No. 442,985, of American Smelting and Refining Co.)

Obtaining Coherent Masses

Metal articles are made from metal powders deposited from solution, for example, copper powder deposited electrolytically, by subjecting the powders to compression while they are still in a moist condition and thereafter sintering the product. The metal powders may be washed with water to remove entrained electrolyte or impurities, and part of the water may thereafter be removed centrifugally. Two or more metal powders, at least one of which is in a wet state, may be mixed and treated, or dry powders may be added to reduce the average liquid content of the mass. The process may be applied also to precipitated alloys, co-precipitated metal mixtures, and to metal powders the surfaces of which have been plated with a dissimilar metal, for example, iron coated with copper. In some cases the powders may be wetted with organic liquids such as alcohol, acetone, benzine, carbon tetrachloride, or carbon disulphide. (See Specification No. 441,177, of Hardy Metallurgical Co.)

Precipitating Metals

In precipitating metals from cyanide solutions by means of a metallic precipitant such as zinc dust, the precipitation is effected with a substantially neutral solution free from dissolved oxygen and containing a salt which serves both as a solvent for the precipitant and also to maintain the solution at a substantially constant hydrogen ion concentration. The salt may be a bisulphite such as sodium or calcium bisulphite. (See Specification No. 442,315, of Merrill Co.)

Corrosion-Resistant Steels

A corrosion-resistant steel contains about 0.01 to 2.0 per cent. of carbon, .07 to 1.0 per cent. of phosphate, .15 to 5 per cent. of copper, .35 to 6.0 per cent. of chromium, 0.35 to 6.0 per cent. of silicon, 0.3 to 8.0 (preferably 1 to 6) per cent. of chromium, not more than 0.5 per cent. of manganese, not more than 0.1 per cent. of sulphur and the rest substantially iron. Small amounts, for example, a fraction of 1 per cent. of nickel, molybdenum nickel and cobalt may also be present. Tungsten may also be present. (See Specification No. 440,194, of U.S. Rustless Steel and Iron Corporation.)

Iron Manufacture

Air enriched to 25 per cent. of oxygen content is delivered by a blast fan mainly to a blast heater and the furnace; part of the air is diverted to a separator, where it is enriched, say, to 42 per cent. oxygen, and the oxygen mixture so obtained is returned to the fan inlet. The separator plant may comprise alternating cold accumulators, and the evaporating oxygen may flow concurrently with its vapours in the separator. If the blast is at relatively high pressure, as in the Thomas converter, the air may be concentrated to 80 per cent. oxygen content. (See Specification No. 440,609, of Ges. Fur Lindes Eismaschinen Akt.-Ges.)

Treating Metallic Surfaces

A bath for producing a phosphate coating on ferrous articles is formed by dissolving in water one or more of the acid phosphates of calcium, strontium, and barium. One or more of the sulphates of zinc, manganese, cadmium, and iron may be added, and the amount added may be such that the bath contains a mixture of acid phosphates of calcium, etc., and acid phosphates of zinc, etc. Alternatively, sufficient sulphate may be added to effect a complete precipitation of the calcium, etc., the bath consisting of the acid phosphate of zinc, etc., with or without an excess of sulphate. An oxidising agent such as a nitrate, nitrite, bromate, chlorate, or iodate may be added to oxidise the hydogen evolved Baths formed and replenished by dissolving varying amounts of calcium dihydrogen phosphate, zinc phosphate, and sodium nitrate are described. The treated articles may be painted, oiled, or lacquered. (See Specification No. 440,215, of F. D. Waterfall.)

Coating with Metals

Chromium is introduced into the surface of articles of iron or steel by heating the articles with solid chromium chloride in a reaction chamber at a temperature of 850° to 950° C. The chromium chloride reacts with the iron and the iron chloride vapours formed are led away through an outlet in the reaction chamber. Alternatively, gaseous chromium chloride, which may be made by passing chlorine or hydrogen chloride over heated chromium or ferro-chromium, is passed into the reaction chamber where it reacts with the iron or steel articles which are heated to 850° to 950° C. If desired, the synthesis of the chromium chloride may be effected in the reaction chamber itself, by passing chlorine or hydrogen chloride into the chamber which contains chromium or ferro-chromium and also the iron or steel articles to be treated. The exterior layer of the treated articles is stated to contain about 40 per cent. of chromium. (See Specification No. 440,641, of E. Hertel and G. Becker.)

Metallurgical Section

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Corrosion of Metals and Alloys

FOLLOWING meetings of the Interallied Conference of Pure and Applied Chemistry in 1919, it was agreed that the American Chemical Society should undertake the production and publication of monographs on chemical subjects, while the National Research Council should be responsible for the preparation of critical tables of chemical and physical constants. The most recent addition to the monograph series (R. J. McKay and R. Worthington, " Corrosion Resistance of Metals and Alloys." Reinhold Publishing Corporation, New York, 1936) relates to the corrosion of metals and alloys. The first part of the book is devoted to a general and theoretical discussion of the phenomena of corrosion, *e.g.*, factors affecting rate of corrosion, forms in which corrosion is manifest, a broad classification of the types of corrosives to which metallic materials are subject, and the factors " internal to the metal " which influence its corrosion-resisting characteristics. The second part comprises a critical review of existing data (already published or supplied specifically for this monograph) on the corrosion-resisting properties of magnesium and magnesium alloys, aluminium and aluminium alloys, zinc and zinc coatings, cadmium plate, tin and tinplate, lead, iron and steel, silicon-iron, molybdenum alloys, chromium alloys, chromium plate, nickel-iron alloys, nickel, nickel-copper alloys, copper, high-copper alloys.

Recent issues of " The Metal Industry " (August 21 and 28, 1936) also contribute a useful review of research on metallic corrosion during the past eight years. In view of the necessity for some limitation in a comparatively short summary of literature which is so extensive, this review is confined to researches which have elucidated the general principles of corrosion and its prevention, and reference to empirical work designed to ascertain the behaviour of particular materials under corrosive conditions has been omitted if such work has not contributed to fundamental knowledge. A useful critical summary of the literature covering 140 references is given.

Physical Constants of Pure Metals

A CONSIDERABLE volume of work on the determination of the physical constants of metals has been carried out in the Physics and Metallurgy Departments of the National Physical Laboratory during the last fifteen years. These determinations relate in part to the specially pure metals prepared in the Metallurgy Department and in part to samples of metals of high commercial purity. Now published in collected form this data covers a range of metals of the highest commercial attainable purity, and includes all of the physical constants yet determined for very pure iron, chromium, manganese, beryllium, cadmium, magnesium and silicon. In addition, there is a summary of data obtained at the National Physical Laboratory and other research institutions for the melting point, latent heat of fusion, specific heat, thermal conductivity and coefficient of expansion of metals of high commercial purity.

For the preparation of the pure iron, crude iron prepared by the electrolytic or by the chemical process, and containing relatively large quantities of oxide of iron, was melted under slightly oxidising conditions in porous crucibles of pure alumina. By this means the more readily oxidisable impurities were retained as oxides, which separated from the metal and were mainly absorbed by the porous material of the crucible. After cooling, the ingot was cleaned from adhering oxide and a thin layer of metal was removed from all surfaces by machining. The iron was then remelted, and a stream of purified hydrogen was passed over the surface of the liquid metal in order to remove the remainder of the oxygen present. A further melting in vacuo was finally given to extract as far as possible any gas left in the iron after the hydrogen treatment.

Pure chromium was obtained by electro-deposition and treated with hydrogen to remove oxygen; a typical analysis showed carbon, 0.004; insoluble residue (chiefly chromic oxide), 0.01 to 0.03 per cent.; sulphur, iron, aluminium and lead undetectable in 10 grams. Manganese was distilled in vacuo, the total impurities being less than 0.01 per cent. For beryllium the remelted cathode metal contained 99.6 per cent. of beryllium (as metal), 0.1 per cent. of beryllium (as oxide), 0.2 per cent. of oxygen (as oxide), 0.05 per cent. of carbon, trace of silicon, 0.01 per cent. of iron, trace of aluminium, and 0.005 per cent. of nitrogen. Cadmium was used as metal of 99.98 per cent. purity. Commercially pure magnesium was further purified by subliming the metal in vacuo at a temperature in the neighbourhood of 600° C.; by subliming three times, the purity was raised from 99.93 per cent. to 99.97 per cent., and a spectroscopic examination showed that, while the iron was greatly reduced in quantity by this treatment, the copper content was not appreciably altered.

Cast Iron at Elevated Temperature

THE corrosion of cast iron at high temperatures was discussed during a recent meeting of the Belgian Society of Engineers and Industrialists. According to Dr. Thyssen, director of the Cast Iron Research Centre, University of Liége, grains of graphite which adound in certain cast iron form the starting point of rupture. Between these grains are found pure iron and iron carbide. When cast iron is heated at 700° C. the iron carbide has a tendency to decompose; on the other hand, oxygen penetrates into the graphite grains and connects them. In the layer directly subjected to the fire alpha iron is changed into gamma iron. Since these two allotropic forms have different physical

constants, they produce variations in the specific volume of the mass of metal and cause it to scale and break. For cast iron used at temperatures below 700° C., the addition of silicon, manganese, or chromium, gives good results in corrosion resistance. For temperatures above 900° C. nickel has occasionally been used, but the addition of nickel lowers the transformation point of the alpha iron. Silicon, aluminium and chromium, on the contrary, raise this transformation point and their action is more favourable than that of nickel. These observations have been confirmed by a large number of tests in the Metallurgical Laboratory, University of Liége, where it is believed that if the causes of the corrosion are properly understood and the remedy is decided upon there still remains the necessity of finding the element which can appreciably improve the mechanical properties of cast iron destined for use at high temperatures.

Paints for Iron and Steel Protection

SOME practical information about the protection of steel and iron by means of paints and other preservatives is given in the 15th Report of the Committee of the Institution of Civil Engineers. It was found that steel plates which have once been exposed to corrosion should be thoroughly cleaned by sand-blasting before applying a protective coat. Painting over mill scale was unsatisfactory as compared with painting on steel from which the scale had been removed. Multiple coats of paint were more protective than single coats. The dilution of the pigment with 12.5 per cent. of kaolin, silica, or mineral white, exerted no appreciable effect on the protective power of the paint and there was little to choose between the various iron oxides. Red and white lead paints were rather superior to ferric oxide in air and half-tide tests, but somewhat inferior in the complete-immersion tests. Red lead containing 65 per cent. of Pb_3O_4 proved superior to that with a higher Pb_3O_4 content. Red lead paints, moreover, were superior to white lead paints in air and in half-tide tests, while in the complete-immersion tests the reverse obtained. Lead chromate paints yielded promising results. Coal tar gave excellent results and behaved better than iron oxide and lead paint, tar from horizontal retorts being superior to that from vertical retorts, irrespective of whether applied hot or cold. It was found that oil paint could be satisfactorily applied to a tarred surface after the latter had been treated with three coats of shellac.

Proprietary Alloys

A DIRECTORY recently published under the auspices of the American Society for Metals (N. E. Woldman and A. J. Dornblatt, "Engineering Alloys: Names, Properties, Uses," 1936) comprises a compilation of "available data and information on practically all proprietary commercial and technical alloys manufactured in the United States, and on many alloys made in other countries, including England, France, Germany and Sweden." The contents includes an alphabetical list arranged according to trade name of alloy, with index or serial number; an alphabetical list of alloys, showing trade name, composition, properties, uses and a key number designating manufacturer; a list of alloys classified according to typical uses or special characteristics, *e.g.*, corrosion-resistance; an alphabetical list of manufacturers, with the names of alloys manufactured; a useful bibliography, and notes upon the classification of corrosion and heat-resisting alloys. Information upon more than 8,000 alloys is embodied in this book, which is believed to be the most extensive publication of its kind ever prepared.

Metallurgical Coke

THE very moderate increase in British coke production compared with the substantial rise for exports of metallurgical coke, and of demands for such coke in the heavy industries, continues to give indication of a possible scarcity. In 1935 a total of nearly twelve million tons of metallurgical coke was produced from British ovens, showing an increase of about 3.7 per cent. over the 1934 output. During the same period the production of the British pig-iron industry, in which about 60 per cent. of the British-produced coke is consumed, increased by 7.7 per cent., from six million tons in 1934 to nearly six and a half million tons in 1935. Exports of metallurgical coke, which comprise over three-quarters of the total coke exported, were just over one and a half million tons in 1935, and compared with 1934, an increase of almost 15 per cent. Exact figures of the coke used outside of the heavy iron and steel industry are not available, but the foundry trade, which uses large quantities of coke in cupolas to melt down pig-iron and old cast-iron, is computed to use well over two million tons of metallurgical coke per year.

It is estimated that about 55 per cent. of the total British output of metallurgical coke is controlled by the iron and steel companies. Among notable new producing units which have come into operation during the present year are those of William Dixon and Co., at Glasgow, and of the United Steel Companies, at Workington. New plant has also been planned in Scotland, on the North-East Coast, in Northamptonshire, and in South Wales, but even so there is little anticipation that these new plants will bring any immediate change from a scarcity to abundance in the matter of supplies of metallurgical coke.

Electrolytically Refined Aluminium

A NEW process for the electrolytic refining of aluminium has been put into operation at St. Jean de Maurienne, France, and it is claimed that the bulk of the metal produced is 99.995 per cent. pure. The electrolyte contains substantial quantities of barium chloride, a typical bath consisting of aluminium fluoride 23 parts, sodium fluoride 17 parts, and barium chloride 60 parts. The main advantage of this electrolyte lies in the fact that the bath can be maintained in a suitably fluid condition at a temperature of 750° C. This lower working temperature allows a reduction in the maintenance costs for the refractories employed, crude magnesia brick being permissible. The anode alloy contains an average of 33 per cent. of copper. The cells operate at an intensity of 40 amperes per square decimetre and nine volts, a current of 10,000 amperes being employed. In addition to its high degree of purity the aluminium produced is claimed to possess a much superior electrical conductivity in comparison with aluminium refined by ordinary methods; it is also said to be extremely resistant to certain acids and alkalies and also to the corrosive action of sea water.

The Institute of Metals : Paris Meeting

Autumn Lecture Reviews the Scientific Organisation Works

THE 15th Autumn Lecture of the Institute of Metals was delivered by Professor P. A. J. Chevenard on the occasion of the Paris Meeting, September 14-18, his subject being "The Scientific Organisation of Works."

The objective of science in an industrial enterprise, said Professor Chevenard, can be defined in two words, to maintain and to improve. To maintain is to assure the regularity of the actual work; this is effected by control which prevents deviations in the manufacturing processes, and by investigations which probe the causes of the inevitable failures. To improve is to perfect or remodel manufacturing processes and to create new products; it is preceded by laboratory researches and by subsequent works tests. The engineer responsible for the scientific function, sometimes called the scientific director, has a delicate and complex administrative task. As a disciple of Fayol he refers to the five fundamental operations of the administrative doctrine: foresight, organisation, command, co-ordination, control.

Foresight

The director of a works should prepare them to utilise at an opportune moment any new idea, to satisfy the future needs of customers, and to frustrate the menace of competition; for these reasons he must have commercial connections and scientific foundations. The scientific director, whose duty it is to prepare these foundations, should take into account the four principal operations of foresight:

(1) Creation of scientific equipment.—The lecturer enumerated the qualities of the apparatus of research and control: accuracy, sensitivity, convenience, robustness, low price, and precision appropriate for the purpose in view. Very often it is advantageous to construct certain apparatus in the works aboratory. For each stage of a process a special apparatus should be used, always in the order of working. The installations should be stable, the erection simple and strong. By using automatic apparatus as far as possible the tests are made more accurate, more rapid, and less costly, errors due to the personal equation are reduced, and the operatives are spared tedious and tiring tasks.

(2) Collection of information for research.—Subjects for research can arise from five principal sources, *viz.*, difficulties of manufacture, the requests of customers, inventions, unexpected facts observed in the laboratory or the workshops, and, finally, as a part of a comprehensive plan of progress. Researches should always be carried out according to the methods of pure science without, however, losing sight of their utilitarian objective. The aim should be not to prepare a simple catalogue of results, but to establish a theory as a base of future progress in the works.

(3 Putting new processes and new products into works' practice.—Taking as an example the development of a new alloy having certain desirable properties, the lecturer described the steps necessary to put its manufacture on a commercial scale. Laboratory and works' scale tests are designed to establish the best conditions for melting, casting, forging, heat-treatment, etc., and these conditions are then summarised in a standard procedure of fabrication.

(4) Establishment of a personnel.—Apprentice courses for juniors, advanced courses for the older employees, and conferences between the senior technical staff assist in developing the scientific idea in a works, and at the same time result in numerous moral and social advantages.

Organisation

The technical function of organisation is preferably divided between the scientific director and the works' manager who work together, under the authority of the managing director, to ensure the smooth operation of the works. The lecturer described the organisation which ensures unity of direction; the scientific director, responsible for the theory, supplies the plans for the engineers of the manufacturing services, but they receive their orders solely from the works' manager, who alone is responsible for taking the necessary measures to have them carried out with regularity, for the best use of the personnel and material, for a low cost of production, and for the time of delivery. The scientific work is divided between the workshops where the experimental results are put into practice, the research laboratory, and the testing and control laboratories.

Command and Co-ordination

The scientific director is in charge of the personnel of the research laboratory, but he also exercises a less direct, but none the less important, action on the personnel of the control and testing laboratories and on the personnel in charge of works' tests. He should endeavour, principally by example, to communicate to all a scientific outlook, he outlines the research programmes and works' tests, defines the plan of unity of control, divides the work between the executives, co-ordinates their activities, collates the results, and, with the aid of the works' manager, draws the necessary scientific and practical conclusions.

Control

The problem of control has two sides, namely, the organisation of the technical control of the manufacturers, and the control in its entirety of the scientific function. The sole means of preventing deviations in the manufacture is to enclose it in the grip of a rigid control. This control extends over the primary materials, the accessory products, products in the course of manufacture, the principal factors in the processes of manufacture, and the finished products; it concerns such elementary properties as the thermal expansion and hardness and such complex properties as the resistance to corrosion and the ease of welding. The methods of control should be quantitative, sensitive and accurate, and their results significant; the lecturer described three types of control apparatus recently built at the Imphy steelworks. As for the control of the unity of the scientific function, the lecturer insisted particularly on the minute precautions which are necessary to prevent the slow deviation of the technique of tests and the methods of control from the standard procedure.

In conclusion, the lecturer emphasised the solemn yet deep satisfaction that is the reward of the research staff, quoting the following words of Lord Kelvin: "In the pursuit of truth the work is its own reward and allows the scientist to accomplish with joy his daily task."

Following the autumn lecture, nine papers on subjects of metallurgical interest were read and discussed.

Conductivity of Aluminium

The influence of small metallic additions on the conductivity of super-purity aluminium was the subject of a paper by G. G. Gauthier, which dealt with the effect on the conductivity of super-purity aluminium (exceeding 99.99 per cent.) of additions of those elements which may occur as impurities in commercial aluminium. It was shown that aluminium follows the universal law that the conductivity and the temperature coefficient of conductivity both increase with the purity. The data presented on the effect of small additions on the conductivity of aluminium are of value in that they have been determined under favourable experimental conditions, owing to the extreme purity of the basis metal and the large amount which has been available. This high purity has made it possible to determine, with a stated accuracy, the effect of each one of the added elements in the almost complete absence of other impurities. Further, the figures given for

iron and silicon, for these elements with titânium and vanadium, and for magnesium and silicon, make it possible to calculate the conductivity of aluminium of accurately known purity.

In a paper on " The Complex Interdependence of the Properties of Alloys and the Industrial Conditions of their Manufacture, Testing, and Use," R. de Fleury and H. Portier gave a study of indirect factors affecting the quality of foundry castings, examination of their reciprocal action and of the importance of their recognition in obtaining sound castings. Utilisation of scrap in the foundry, lowering of the quality of alloys by successive remelting; the use of organised production; control of raw materials; influence of the process of solidification of alloys and of the factors of moulding and casting; and influence of design were dealt with.

Properties Affected by Prolonged Heating

The " Mechanical Properties of Aluminium and Its Alloys after Prolonged Heating " was the subject of a paper by A von Zeerleder and R. Irmann, who investigated the strength of pure aluminium and various aluminium alloys after heating for long periods at 75°-300° C. The strength properties of the same materials were also determined in the state of complete stabilisation, the heating periods extending over approximately two years. After treatments of different duration at elevated temperatures, some specimens were cooled and tested at room temperature; others were tested at the treatment temperature. For complete softening at 250° C., for instance, *i.e.*, to obtain the properties observed in completely stabilised samples, heating periods of at least six months were required in the case of pure aluminium and Anticorodal, and of more than two years for Avional and " Y " alloy. To determine the decrease in strength of any material after heating for long periods at elevated temperatures it was necessary to carry out tests of long duration. The values of the yield-point observed in the normal short time test after heating periods of one year form a basis for calculations for engineers. The permissible loads can be ascertained only by observation of the creep limit, and this property is being studied by the authors.

A description was given by N. D. Pullen of a dual anodic process designed for the treatment of aluminium surfaces in order to produce a high degree of reflectivity. The first bath in which the electrolytic brightening is produced is a mixture of sodium carbonate and sodium phosphate in the approximate proportions of 3 : 1 having a strongly alkaline reaction. The second bath in which a reinforcing film is produced consists preferably of a strong solution of acid sodium sulphate. Data was given showing the reflectivity of aluminium surfaces treated by this method compared with a standard silver mirror and other surfaces such as chromium plate and nickel plate.

Ultra-Light Alloys

A. M. Portevin and P. G. Bastien, in a " Study of the Forgeability of Various Light and Ultra-Light Alloys," endeavoured to determine, by means of laboratory tests, the optimum conditions for hot-working light and ultra-light alloys. With this in view they have now compared the results obtained from static bending and compression tests and dynamic bending and tensile tests, indicating the important part played by the rate of deformation, and showing that the bending test appears to be the most convenient, speedy and sensitive. The tests have been carried out on aluminium; on copper-aluminium alloys containing 6 and 12 per cent. of copper; on aluminium-magnesium alloys containing 5, 10 and 15 per cent. of magnesium; on magnesium; on magnesium-copper alloys containing 5, 10 and 15 per cent. of copper; and on magnesium-aluminium alloys containing 3, 6, and 9 per cent. of aluminium. The methods of testing employed have made it possible to define the capacity for hot-work of these various alloys.

Up-to-date metallurgical information about " Metals of the Platinum Group " was given by R. H. Atkinson and A. R. Raper. After a brief description of the discovery of the metals and an account of the ores, particular attention was devoted to the recovery and refining of the metals produced from the Canadian nickel industry. This was followed by a full description of the methods of fabrication of the metals and their alloys. It was shown that the two ductile metals of the group platinum and palladium are readily worked, while rhodium and iridium are worked with much greater difficulty. The two metals osmium and ruthenium, belonging to the hexagonal system, have not up to the present been thoroughly investigated. Finally, an account was given of the properties of the metals and their uses.

Creep in Tin Alloys

A paper by D. Hanson and E. J. Sandford on " The Creep of Tin and Tin Alloys " described results of creep tests of long duration on tin and some of its alloys in the rolled condition. Silver up to 3.5 per cent. was found to greatly improve the creep resistance of tin. Bismuth-tin alloys are more resistant to flow than pure tin at stresses above about 300 lb. per sq. in., but at lower stresses they are inferior to pure tin. Antimony improves the creep properties of tin: the alloy containing 8.5 per cent. antimony withstands a stress three times that of pure tin for an equal duration. Cadmium-tin alloys are greatly improved by heat treatment and offer considerable resistance to creep. The mechanism of failure of these alloys was discussed. Results were given of tests on lead-tin solders and on the cadmium-tin eutectic alloys: these flow under stresses as low as 130-150 lb. per sq. in. It was shown that in many cases there is no relationship between resistance to creep and ultimate tensile strength.

" Veining and Sub-Boundary Structures in Metals " was discussed by L. Northcott, who has studied the network structure which occurs within the crystals in several pure metals and in many alloys of copper. This structure has been found to be due to the precipitation from solid solution, in a network form, of the oxide of the metal during cooling. The influence of alloying additions on veining in copper has been examined and the effect of heat treatment and recrystallisation on veining correlated with changes in hardness. Similar structures referred to as sub-boundary structures have been observed in a number of other alloys. These structures are due to the precipitation, also during cooling, of a constituent of the alloy.

Salt Bath Heat Treatment

A note on the " Influence of Salt-Bath Heat Treatment on the Corrosion Resistance of Duralumin Sheet " was contributed by A. J. Sidery and B. Evans, who said experiments were carried out to provide information as to whether the use of a nitrate salt bath in the final heat treatment of duralumin has any deleterious effect on the corrosion resistance of the material as compared with that of material which has been heat treated in an electric furnace. The influence of salt residues on the surface of the sheet during prolonged storage was also investigated. It was found that the use of nitrate salt baths has no deleterious effect, but that salt residues are liable to foster local surface-pitting of the material during storage.

THE soybean crop estimate of Manchuria for 1936 has been revised recently, and it is now estimated that the total yield will approximate 4,300,000 short tons in contrast with the revised estimate of 3,000,000 tons for the 1935 crop. Other recent estimates for the 1936 Manchuria crops were that the perilla crop will total 133,481 metric tons, a reduction of 47,935 tons from the 1935 crop, and the hempseed crop, estimated at 40,906 metric tons, a decrease of 4,343 tons from the 1935 yield.

The British Cast Iron Research Association

Annual Report for the Year 1935-36

IN its 15th annual report, for the year 1935-36, the British Cast Iron Research Association states that income has been the highest yet reached in the history of the association, and the minimum of £7,000 from industrial grant-earning subscriptions, required in order to earn the grant of £5,000 from the Government, was obtained without the necessity for a special appeal to members. The council therefore express the hope that the increased prosperity of the industry, the country's tariff policy and the need for greater scientific knowledge in the industry to keep pace with foreign developments, will induce all eligible firms to support the association as members.

Research and Development

The most fundamental investigation being conducted by the association is that on the formation of graphite in cast iron and its modification. The process evolved for the refinement of graphite by the incorporation in the melt of a small amount of titanium and subsequent treatment of the melt by means of an oxidising gas, referred to in the last report, has led up to a theoretical explanation on the following lines.

It is suggested that graphite originates not, as proposed in an earlier theory, from undissolved graphite nuclei, but from particles of a crystalline, but non-metallic character. The titanium process effects a remarkable refinement of graphite from the coarse to the extremely finely divided state, probably by the formation, during the gas treatment, of a low-melting titanium slag which envelops the non-metallic particles already present. Because this envelope is fluid the particles are prevented from exerting an inoculating action, thus permitting the metal to solidify in the super-cooled state, the graphite assuming a very finely divided form. The original coarse structure can be reproduced by treatment of the melt with hydrogen, which has a reducing action on the slag envelopes.

Non-Metallic Inclusions

Various other pieces of evidence support the view that coarse graphite originates from non-metallic and particularly from silicate inclusions. For example, if an iron, extremely low in silicon, be graphitised wholly by nickel, the graphite takes the same finely-divided super-cooled form as that found in the titanium process. The same remark applies to aluminium, if care is taken to exclude its oxide. In the presence of silicon both elements yield a coarse graphite structure. Furthermore, when an ordinary grey cast iron contains copper below the limit of solubility, the graphite, although refined compared with a copper-free iron, retains its essentially flake character.

In the presence of copper, however, in excess of the solubility limit, the graphite assumes the super-cooled or finely divided form. The suggestion again is that the excess copper thrown out of solution coats the non-metallic inclusions with an envelope which is fluid at the temperature of solidification of the melt. There is reason to believe that, although white iron does not contain free graphite, an analogous change occurs in white iron when subjected to treatment on similar lines.

Undissolved Graphite

Although the theory of the undissolved graphite particle as the origin of graphite flakes has been abandoned, the nucleus theory still holds, the non-metalic inclusion now being regarded as the nucleus. The work reported above on the production of fine graphite structures is expected to throw a good deal of light on the production of high quality irons of the inoculated type.

This work throws into prominence the non-metallic inclusion as the focus of metallurgical interest, and the same position holds with regard to steels and non-ferrous metals. The work has been reported to the Institute of British Foundrymen and to the Iron and Steel Institute, by Dr. A. L. Norbury, the senior metallurgist, and Mr. E. Morgan, and the process is covered by Brit. Pat. 425,227. In view of the importance of the non-metallic inclusion, its nature and distribution, apparatus has been set up for the purpose of separating non-metallic inclusions from pig and cast iron with a view to their subsequent analysis, and several separations and analyses have now been made.

Ingot Moulds

By arrangement with the Iron and Steel Industrial Research Council of the British Iron and Steel Federation, the process of refinement is being applied in the manufacture of ingot moulds, to see whether the refinement of the graphite will diminish the disintegration of the mould surface due to the attack of molton steel. A series of ingot moulds has been made, both treated and untreated, and these are now in service. There are special difficulties in realising the formation of super-cooled graphite from the cupola, but it should not be necessary to go the whole way from coarse to extremely fine in order to obtain a useful improvement. The Metallurgy Research Board of the D.S.I.R., of which the director of the B.C.I.R.A. is a member, has approved of a group of members of the board, representing both ferrous and non-ferrous practice, giving special attention to and interchanging views and ideas on non-metallic inclusions.

Grey Cast Iron Standards

The association is assisting in the revision of British Standard Specification No. 321 for grey cast iron, and in the formulation of specifications for high duty irons for gear wheels and general castings, both plain and alloyed. The data derived from a series of tests undertaken in conjunction with Vickers-Armstrongs, Ltd., Barrow-in-Furness, has been of value in this connection, and it is hoped shortly to present a complete report on these tests.

The necessary preliminary work on the influence of copper on cast iron has been completed and reported to members and a report on the influence of molybdenum is in draft. The work on copper is now being completed. Experience on the influence of aluminium in cast iron had shown the desirability of undertaking a more extended investigation than has hitherto been possible and this was begun during the year. Aluminium irons have properties which are likely to be of considerable value in the industry, but their use has been rendered virtually impossible by the readiness with which aluminium oxidises during melting. This causes inclusions of aluminium oxide in the metal, with accompanying porosity, and yielding inferior mechanical properties. The investigation has, therefore, first been directed towards overcoming this difficulty, with very promising results.

Melting Practice

The work reported as started last year by the Melting Practice Sub-Committee on the melting quality of a series of metallurgical cokes, undertaken in conjunction with the London, Midland and Scottish Railway Company, at Derby, has been completed and the data is now being examined and a report prepared. Some of the tests have been kindly carried out by the Northern Coke Research Committee. The Rotary Furnace Panel of the Melting Practice Sub-Committee has held three meetings and has discussed the problems involved in the metallurgical control of these furnaces, including the question of linings.

The last annual report of the B.C.I.R.A. recorded that 95 balanced blast cupolas were installed or under construction, with an aggregate hourly output of 670 tons. The total

number installed or under construction at the present time is 141, with an aggregate hourly capacity of 1,078 tons. The situation with respect to metallurgical coke lays further stress on the importance of economy which this furnace offers.

Moulding Sands

Considerable progress has been made in an investigation on the use of certain naturally-occurring clays as bonds for moulding sands, both natural and synthetic, and a number of reports have been considered by the Sands and Refractories Sub-Committee. Towards the end of the year, Dr. J. G. A. Skerl, who had been in charge of research and development work for the association on moulding sands and refractories, first at Sheffield and later at headquarters, left to take up an industrial appointment. Dr. Skerl remains a member of the Sub-Committee. In June, 1936, Mr. W. B. Parkes was appointed to take his place. Mr. Parkes has had considerable experience in moulding and core sands and refractories for both iron and steel founding at the Austin Motor Co., Ltd., and has already been of considerable assistance to members requiring advice on sand problems.

The problem of refractory linings for cupolas, rotary furnaces, etc., has also had attention, mainly by way of examination of samples from members, the service life of which is known.

The Association's Laboratories

During the year the chemical laboratory carried out between four and five thousand duplicate estimations, and in the metallographical laboratory over 1,100 micro-examinations were made. In the mechanical testing laboratory about 2,000 tests of various kinds were conducted. Over 200 melts were made in the melting shop and cupola. In the sands laboratory about 1,000 tests for strength, permeability and mechanical analysis were made on sands and refractories supplied by members, in addition to over 1,300 tests in connection with the sands research programme. During the year the chemical laboratory has been extended and equipped for the study of non-metallic inclusions in pig and cast iron. The microscopic laboratory has been equipped with a Vickers photomicrographic apparatus. A very small cupola has been made and an oil-fired crucible furnace installed.

As superintendent of the Falkirk laboratory, Mr. H. Cowan is fully engaged on visits to and work arising out of problems from Scottish members. The contact between Scottish members and the Falkirk laboratory has been strengthened by arrangements made during the year to distribute circulars and reports to all Scottish members direct from Falkirk.

Future Developments

The Council of the Institute of Vitreous Enamellers has considered the desirability of making provision for the conduct of research on vitreous enamelling, a type of finish now widely applied to cast iron. Representatives of the Institute have discussed with the director the possibility of linking up with the association for the conduct of this work, and have been given the fullest possible assurances of the association's interest and of the practicability of a scheme of the nature outlined. This matter was referred to by Dr. J. W. Mellor, F.R.S., president of the Institute, and Mr. W. H. Whittle, chairman of the council, in reports given in the *Foundry Trade Journal* for Octboer 8, 1936.

The Annual Luncheon

Lord Dudley, the newly-elected president, presided at the annual luncheon of the Association at the Hotel Victoria, London, on Thursday, and the principal guests included Lord Austin, Sir Harold Brown, Sir Harold Carpenter, Sir Alexander Gibb and Engineer Vice-Admiral Sir George Goodwin.

LORD DUDLEY recalled that it was his ancester, Dud Dudley, who, in 1619, developed the substitution of coal for charcoal in the treatment of iron, and thus laid the foundation upon which the great iron industry of the present day had been developed. He himself started his business life in a foundry in the Midlands, which, among other things, produced engine castings for Lord Austin, and he was pround of his close association with the foundry industry. When steel makers were buying plant which embodied a large amount of cast iron they would always prefer to buy British, but they must have the latest and best plant because they had to compete with countries which had the latest and best, and if British producers could not supply it they had no option but to go abroad. They could not produce those things that were so essential unless they supported to the fullest possible extent those scientific and research departments which gave them the ability to provide them.

They had all been through a very thin time since the war ended, and, in fact, before the war from the research point of view. They had not had the money to put into research during recent post-war years. They had not had the opportunities for the development of science as it should be developed. Other countries had had better opportunities and many of them were in advance of us in many respects. We were, however, standing on a better wicket than they were today and it was up to us to pick up our lost ground and put ourselves once more in the pre-eminent position as regards invention, research and scientific development that we had held since the beginning of time.

He hoped they realised the importance of collective action in that respect. In olden days we had the benefits of wonderful individual discoveries, but those days were rather over and it was only by collective action, by pooling their collective resources, that they could once more take their position in the competition of the world. It was no use for any country to think that by individualism it could succeed against collective action from competitive countries.

Referring to the first report of the British Foundry School, sponsored by the Association, Lord Dudley said the school deserved the fullest possible support from every branch of the Association, and during his presidential year he would make it his business to assist that side of their activities to the best of his ability.

SIR ALEXANDER GIBB proposed and Sir William Larke seconded a vote of thanks to Lord Dudley for his speech, and the president briefly replied.

Some Recent Metallurgical Patents

Treating Metallic Surfaces

A RUSTPROOFING composition is prepared by dissolving iron sulphide in a concentrated aqueous solution of phosphoric acid or by dissolving iron or another iron compound in the acid and adding a sulphide, for example, sodium, potassium, or calcium sulphide, either during the reaction or subsequently. The solution is filtered and, when required for rustproofing, is diluted, the articles being immersed in the diluted solution which is maintained at an elevated temperature. *e.g.*, 100° C. Sodium carbonate may be added to the solution at the time of its application. (See Specification No. 447,176, of W. I. Walters.)

Non-Oxidising Alloys

AN alloy which is resistant to oxidation at high temperatures and is completely or almost completely non-hardenable consists of iron, 3.5 to 20 per cent. of chromium, less than 0.1 per cent. of carbon, and less than 1 per cent. of vanadium, the vanadium content being at least 10 times the carbon content. The iron may contain the usual impurities, *e.g.*, 0.2 to 0.26 per cent. of silicon and 0.37 to 0.47 per cent. of manganese. The chromium content is preferably between 3.4 and 7.5 per cent. Specific examples of the alloys are given and also examples of alloys containing iron, chromium and carbon and iron, chromium, carbon, and vanadium which do not fall within the scope of the invention. The alloys may, for example, be used for making sheets and tubes for use at elevated temperatures and for welding rods. (See Specification No. 447,265, of Electro Metallurgical Co.)

Metallurgical Section

December 5th, 1936

The Spectrographic Analysis of Tin

Work done on the spectrographic analysis of tin by the British Non-Ferrous Metals Research Association has now been extended to include the quantitave determination of small amounts of aluminium, cadmium and zinc in tin. These additional researches were carried out by the Association with the aid of funds provided by the International Tin Research and Development Council. In his report, as published by the Council, Mr. D. M. Smith first gives a summary of previous work on the spectrographic analysis of tin, and then deals fully with the greater part of the new work. A revison of the analytical tables for the determination of impurities in tin by means of spark spectra, photographed under the standard conditions previously adopted, forms another section of this publication, which includes a general summary of the work done on the spectrographic analysis of tin and the conclusions reached with regard to technique and analytical methods.

Both arc and spark methods have been investigated from the point of view of their application to the quantitative determination of imprities in tin, with particular reference to aluminium, cadmium and zinc, over the range 0.001 to 1.0 per cent. Spark spectra, photographed under the standardised conditions of excitation as described in the report, are recommended for the routine determination of aluminium, cadmium and zinc. In the graphite are method, previously found satisfactory for the determination of a number of impurities in tin, irregularities in arc spectra were observed in the case of aluminium and zinc. "Synthetic spectra" were used as a means of checking the composition of the standard alloys with regard to aluminium, cadmium and znc, and also as a means of accurately intepolating the percentages at which certain pairs of lines become of equal intensity; this method could be readily applied, if required, to other impurities in tin. The routine method of analysis which is advocated is the so-called "internal standard" method, refined, if necessary, either by the direct comparison of spectra of samples with those of selected standard alloys or by the application of the synthetic spectrum method.

An electrolytic method of refining tin in the laboratory for the purpose of obtaining spectrographically pure tin for use in the preparation of standard alloys containing very small amounts of the alloying constituents, is described in an appendix to Mr. Smith's report. It is stated that various samples of tin were tested spectrographically for the presence of impurities and it was found that small quantities of lead, bismuth and copper were invariably present, even in the highest grades of pure tin. The purest sample commercially available was "Chempur" tin, and although this represented very high grade material, its spectrum showed faint lines due to lead, bismuth and copper as impurities; for the purpose of this particular research, however, it was desirable to obtain material which was spectrographically free from such impurities.

Preliminary experiments on the electro-deposition of tin were carried out with a view to obtaining solid crystals which would not adhere too closely to the cathode upon which they were deposited. Furthermore, the use of magnesium chloride, boric acid, or sodium stannous chloride, as additions to the electrolyte was avoided in view of the possibility of introducing traces of further impurities in the deposits. Since the purity of the electrolyte determined the purity of the deposit, an electrolyte composed of distilled water (3,000 c.c.), concentrated hydrochloric acid A.R. quality (500 c.c.), concentrated sulphuric acid A.R. quality (10 c.c.), and ammonium chloride (25 g.) was finally adopted, all these materials being spectrographically lead-free. Ammonium chloride was added to improve the deposit and to diminish the tendency to short circuiting by the "streamers" from the cathode.

Too high a current gave a rapid dull grey deposit with much gassing; the best crystals were obtained when no gassing occurred. Carbon rods were used as cathodes, the rods having been previously purified by prolonged soaking in hydrochloric acid and distilled water, until the arc spectrum of the carbon showed silicon to be present in small quantity and faint lines due to iron, magnesium, calcium, manganese and aluminium. During the daytime a current of about 1.2 amps. was used; while unattended at night the current was 0.7 amps. This gave solid needle-like crystals which were readily detached from the carbon rods. These crystals were washed with distilled water and melted in a graphite crucible and allowed to solidfy without flux, and very little oxide was formed. Re-melted *in vacuo* in Pyrex tubes and examined spectrographically, the refined tin was found to be free from bismuth, lead, copper, cadmium, iron, antimony, silver, silicon, manganese, calcium and aluminium. The analysis of a *large sample* showed that lead had been reduced from 0.008 to 0.0026 per cent., antimony from 0.003 to 0.001 per cent., bismuth from 0.003 to 0.0004 per cent., copper from 0.0005 to 0.0006 per cent. and iron was only 0.0003 per cent.

Cast Iron Research

According to its research and development programme for 1936-37, the British Cast Iron Research Association intends to continue the examination of the mechanism of graphite formation with special reference to the influence of non-metallic inclusions present, and to work out the application of the graphite-refining process for various types of commercial furnaces, and for various types of cast iron and pig iron. They will also study the production of graphite-refined and inocculated irons from the point of view of their respec-

tive non-metallic inclusions and the modification of these by ladle additions. Development work, in regard to graphite formation, will be in the direction of applying the graphite-refining process to the large-scale production of ingot moulds, in co-operation with the Iron and Steel Industrial Research Council, and in assisting members to apply it in other appropriate cases to commercial production. Research on the shrinkage and contraction of cast iron will be continued for the purpose of investigating the influence of carbon, silicon and phosphorus, with reference to melting temperature and other conditions, using crucible-melted pig irons. The Association will also co-operate with members in studying practical difficulties due to shrinkage and contraction, and in applying the results of the research to local conditions.

For alloy cast iron it is hoped to complete work on the effect of copper, and on the effect of molybdenum on cast iron, and to investigate the founding, mechanical and other properties of the aluminium cast irons, with special reference to the development of the necessary technique for producing sound structures free from alumina. In melting practice it is proposed to examine the properties of a series of furnace refractories in relation to their service life, and to continue the development of the balanced blast design of cupola. In addition to this work an effort will be made to complete the investigation of the properties of naturally occurring clays as used for the bonding of synthetic sands, and subsequently to compare them with the clays present in the natural sands.

Iron Making at Low Temperature

FOLLOWING several years of patient effort, it is now reported that iron manufacture by low temperature reduction as exploited by the Duffield Iron Corporation has been definitely proved for commercial development on a large scale. This process consists of producing semi-molten iron of exceptional purity direct from the iron ore, and melting the hot product electrically. The resultant iron ingot used in the fabrication of high quality metal sheets for cold pressing, as required by the motor and other industries, or alternatively, forms the base of stainless, high-speed, copper-silicon, molybdenum, and other high-class steel alloys. The characteristics of this raw material, its commercial value and its cost are set out in a report which the directors have issued to shareholders. In this report, Mr. G. C. Castle, foundry consultant, estimates that the cost of production of iron ingots, 99.84 per cent. purity, from local ore at the company's disposal will be 63s. 9d. per ton, which is equal to 78s. 9d. per ton delivered. The satisfactory production of metal sheets from iron produced by the company's process will now enable the directors to proceed with financial arrangements for the establishment of a subsidiary company equipped for an initial production of 1,000 tons per week of iron ingots to be marketed under the proprietary name of "Demco."

Thickness of Electro-Deposited Coating

The drop method proposed in 1933 for the determination of the thickness of electro-deposited coating, but developed hitherto only for the testing of cadmium and zinc on steel, has now been modified and extended to make it applicable to the testing of electro-deposited nickel, copper and bronze coatings. In the modified test, as described by Mr. S. G. Clarke (Electro-depositors' Technical Society, October, 1936), a stream of the selected corroding reagent, emerging from a small jet, is allowed to impinge on the surface of the work. Automatic jet projection obviates the necessity for regulating the rate of dropping, and gives improved definition at the point of perforation of the coating. The rate of perforation is also increased by the jet attack, a factor which is of some importance when testing resistant metals such as nickel or chromium. Coatings of commercial thickness are stated to require from one to two minutes for peforation.

The apparatus and precedure for this testing method are the subject of a patent application, and both apparatus and solutions are shortly to be made available commercially. For use on nickel coatings, the corroding solution contains ferric chloride (150 g.), copper sulphate crystals (100 g.) and glacial acetic acid (250 c.c.) per litre. Details of end-point detection for nickel coatings on steel, copper, brass, aluminium and zinc-base die castings are given in Mr. Clarke's paper, as well as particulars of procedure with reference to copper, bronze and cadmium coatings. As a result of the experimental work reported, it has been possible to establish the time required for perforating coatings of known thickness over a temperature range of 10°-40° C., and curves which have been worked out for each of the corroding solutions give a ready calculation for thickness from a note of the time taken to perforate the coating at prevailing temperatures.

Pitting of Electro-Deposited Nickel

The mechanism of pitting on electro-deposited nickel has been studied recently by means of the microscopic examination of sections parallel to and vertical to the surface of the deposit, and the results of this investigation were reported to the Electrochemical Society (October, 1936). Pitting, states Mr. M. Cymboliste, is attributed to the adhesion of some of the bubbles of hydrogen or other gases formed during electro-deposition, the adhesion being due to the existence of some defect in the basis metal at these points, or in the deposit itself. The irregularities which tend to cause adhesion of the gas bubbles, with ultimate production of pitting, fall under the headings of (1) foreign particles on the surface of the basis metal; (2) physical irregularities in the basis metal surface, e.g., nodules or cavities; and (3) a variation in the metallic constituents present in the surface of the basis metal. Discussing the formation of pits on the surface of the electro-deposit, Mr. Cymboliste shows that gas bubbles may continue to adhere without increasing in volume, or that they may grow in size and either remain attached to the surface of the work or detach themselves and escape from the solution. The use of a thin interlay of copper between two coats of nickel is recommended as a means to prevent pitting.

IT is reported that the Japanese electrolytic caustic soda producers, in order to cope with the severe competition from foreign companies, recently arrived at a decision to place exports of electrolytic soda under control through the Co-operative Sales Company. Under the control scheme it is believed that from 500 to 1,000 metric tons of caustic soda will be available for export each month. Producers employing the ammonia-soda process are not joining the sales organisation.

Metals of the Platinum Group*

By R. H. ATKINSON and A. R. RAPER

THE six metals of the platinum group are white in colour and are permanent in air under normal atmospheric conditions when in compact metallic form. As would be expected from their position in the Periodic Table, their chemical properties are similar. For instance, rhodium, ruthenium, and iridium are not attacked by *aqua regia*; platinum is dissolved by *aqua regia* but is not attacked by any single acid; palladium is easily soluble in *aqua regia*, and it is also attacked by hot concentrated sulphuric acid and to a less degree by nitric acid, but with these exceptions it is resistant to the common acids. The metals in the finely divided state are less resistant to chemical attack than the compact metals; for instance, osmium black dissolves in nitric acid and rhodium black is attacked by hot concentrated sulphuric acid. In solution the metals readily form very stable complex salts, many of which are isomorphous. For this reason clean separations of the metals are rarely accomplished.

It will be obvious from this brief reference to the chemical properties, that the refining of the platinum metals is likely to be a complicated chemical process. Electrolytic refining methods which are so helpful in the case of many other metals cannot be used because palladium is the only one of the group which easily dissolves anodically in an aqueous electrolyte. Further, all the metals have relatively high melting points ranging from 1,550° C. for palladium to 2,700° C. for osmium; consequently it is customary to market the metals in the form of sponge or meal and they are not melted until required for fabrication.

Extracting and Refining

The Acton refinery of the Mond Nickel Co. receives residues from the Clydach nickel refinery, as well as precious metal concentrates from the electrolytic nickel refinery, and a smaller amount of concentrates from the electrolytic copper refinery which treats the company's blister copper.

The residues from the Clydach refinery require further concentration before the platinum can be extracted economically with *aqua regia*. For this reason the residues are smelted with litharge, fluxes, and charcoal in small basic-lined tilting furnaces to collect the precious metals in lead and at the same time to slag off silica and base metals. Subsequent cupellation of the ingots in similar furnaces removes the excess of lead as litharge (which is used again in further smelting charges) and yields a silver-rich precious metal alloy about four times richer than the Clydach residue. This alloy is parted with boiling concentrated sulphuric acid, which removes most of the silver and about one-third of the palladium as sulphates. The residue contains the platinum, gold, and the rest of the palladium in a form particularly suitable for extraction with *aqua regia* which is the next operation.

From the solution of chlorides thus obtained, the gold is precipitated as brown gold by means of ferrous sulphate, and then the platinum as ammonium chloroplatinate by the addition of ammonium chloride, and lastly, the palladium is precipitated as palladosammine chloride. The only one of these operations which calls for special comment is the precipitation of palladosammine chloride. The palladium present as chloride is converted into soluble tetrammino-palladous chloride by the addition of excess ammonia solution according to the equation.

$$PdCl_2 + 4NH_3 = [Pd(NH_3)_4]Cl_2.$$

When excess of hydrochloric acid is added, the sparingly soluble yellow compound known as palladosammine chloride is precipitated according to the equation

$$[Pd(NH_3)_4]Cl_2 + 2HCl = [Pd(NH_3)_2Cl_2] + 2NH_4Cl.$$

The impure platinum salt is converted into metal by ignition, dissolved in *aqua regia* and re-precipitated as pure ammonium chloroplatinate, which, on ignition, yields pure platinum sponge. The impure palladosammine chloride is purified by dissolving in ammonia and re-precipitating with hydrochloric acid; the pure salt is converted into sponge by igniting.

The silver and the gold are purified electrolytically, by the Moebius and Wohlwill processes, respectively, special attention being given to the recovery of small amounts of platinum metals.

The final insolubles and reduction residues from the above wet process treatment are smelted to concentrate the rhodium, ruthenium, and iridium (which are known as by-metals). From the precious metal alloy thus obtained, the individual metals are separated and refined by chemical processes. Refining of the richer concentrates from the nickel and copper refineries which contain more than 50 per cent. platinum metals and very little silver, commences with the *aqua regia* treatment.

In precious metals refining, the order of operations depends on the ratio in which the precious metals are present. The order which is here described is followed because it has been found to be the most suitable for these by-product concentrates, although it is realised that other sequences of operations might be more suitable for other types of material. The average purities of the metals from these concentrates are: platinum 99.93, palladium 99.94, iridium 99.7, rhodium 99.7, ruthenium 99.7, gold 99.97, and silver 99.97 per cent.

The high intrinsic value of the materials treated makes it imperative to reduce working losses to a minimum and to obtain the maximum yield as quickly and directly as possible. In practice, not more than 0.25 per cent. of the platinum metals contained in the concentrates is lost, while 1.25 per cent. is temporarily retained in furnace slags which are returned to the nickel refinery for re-treatment. The remaining 98.5 per cent is produced directly as refined metal. The losses occurring in the processes of extracting the nickel and copper are also very small, and it is estimated that 90 per cent. of the precious metals contained in the ore is ultimately recovered.

Palladium

With the development of the oxy-hydrogen blowpipe it became quite easy to melt palladium in quantity since the melting point is 1,553° C., some 220° C. below that of platinum. Palladium is usually melted on a lime hearth and cast into graphite moulds. Various precautions are necessary to prevent gas absorption. Palladium is usually regarded as a metal with a high affinity for hydrogen, and, while this is true at low temperatures, in a state of fusion it readily dissolves oxygen. This gas is largely liberated during solidification and the metal may swell to twice its original volume. As in the case of silver, no oxide phase can be detected microscopically in the solidified metal. By suitable control of flame composition, oxygen absorption can be largely eliminated. During melting there may be an appreciable loss by volatilisation, so that quite apart from other considerations the metal should not be overheated.

Palladium can be readily melted with an oxy-coal-gas flame, but there is a definite danger that sulphur contamination will occur. In this respect palladium is more sensitive than platinum. A very small content of sulphur leads to the formation of a brittle compound[5] Pd_4S, which usually separates along the grain boundaries. This compound is insoluble in palladium and melts at 785° C. Even 0.02 per cent. of sulphur leads to hot-shortness and at room temperatures reduces

* From a paper presented at the Annual Autumn Meeting of the Institute of Metals, at Paris, September, 1936.

[5] F. Weibke and J. Laar, *Z. anorg. Chem.*, 1935, **224**, 49.

the ductility of the metal.[6] For melting in the high-frequency induction furnace, the refractories mentioned in the case of platinum give good service. Graphite crucibles cannot be used since carbon is so readily picked up.

A satisfactory annealing treatment for pure palladium consists in heating in air to 800° to 900° C. for five minutes.[4] Annealing at temperatures above 1,000° C. results in a pronounced decrease in elongation owing to the onset of marked selective grain-growth. Below 1,000° C. the grain-size remains very uniform. A slight surface discolouration occurs during cooling owing to the formation of a thin palladium oxide film. If this is objected to, the metal may be heated and cooled in nitrogen. Palladium alloyed with other metals of the platinum group, *e.g.*, rhodium and ruthenium, requires a higher annealing temperature. With 5 per cent. of added metals the annealing temperature is increased to 1,000° to 1,100° C.[4]

Rhodium

Rhodium can be melted readily in the high-frequency induction furnace. Thorium oxide crucibles are the most satisfactory though, with care, zirconium oxide crucibles can be used. Melting in air leads to the same troubles due to dissolution of oxygen as in oxy-hydrogen melting, but if the metal is frozen slowly forgeable ingots are obtained. If melted *in vacuo* (about 1 mm. of mercury pressure) a smooth silver-white surface is obtained. In the case of small vacuum-fused ingots, large shrinkage cavities make forging difficult, hence it may be necessary to remelt on a lime hearth.

It should be noted that molten rhodium has a considerable affinity for carbon, a property shared by the other metals of the group. Rhodium melted in an Acheson graphite crucible increased in weight by 1.8 per cent.[7] The button was very hard and brittle and could not be forged either hot or cold. The colour of the metal was noticeably darker than that of pure rhodium. The forging or swaging of rhodium ingots does not present any unusual difficulties. They cannot be forged at room temperature, but become quite malleable above a red heat.

Iridium

Early attempts to fuse iridium were unsuccessful, but from 1837 onwards it was known that a fusible product could be obtained by adding phosphorus to very hot iridium sponge.[8] This recalls the early use of arsenic in the metallurgy of platinum and of sulphur in the metallurgy of palladium. The phosphorus process was later elaborated by Holland for the manufacture of iridium alloy grains suitable for tipping fountain pens.[9] The fusible alloy contains about 7 per cent. of phosphorus, and can be cast into thin plates, which are very brittle.

It is clear that iridium can best be worked at a white heat. As a starting point either sintered sponge or fused metal may be used. In connection with the melting of iridium it should be noted that the melting point (2,454° C.)[10] is very close to the maximum temperature of the oxy-hydrogen flame. Iridium can be more readily melted with the oxy-acetylene blowpipe and, provided that care is taken to adjust the flame composition, the ingot so produced is quite malleable at a white heat. The dissolution of carbon and oxygen during melting should be avoided as in the case of the other metals of the group.

Ruthenium and Osmium

The freezing points of these metals are not known, but the difficulty of melting the metals with a blowpipe indicates that ruthenium melts at a somewhat higher temperature than iridium, while osmium is the most infusible metal of the group. Deville and Debray[1] melted very small quantities of ruthenium with an oxy-hydrogen torch, but were unable to fuse osmium. During the melting of ruthenium there was a considerable loss of metal as ruthenium dioxide and tetroxide and on freezing it spitted like rhodium. It was very hard and brittle. Osmium sintered on heating to a temperature estimated to be equivalent to the melting point of rhodium (1,966° C.), and the metal had a pronounced metallic lustre showing a bluish tinge. On melting ruthenium in a graphite crucible in a high-frequency induction furnace, it dissolves about 1.2 per cent. of carbon, thus conforming to the general behaviour of the platinum metals.

Properties and Uses of Platinum

The physical properties of the platinum metals are, as might be expected, very dependent on purity; consequently those uses of the metals which depend on specific physical properties demand products of extremely high purity.

In Germany an attempt has been made to draw up specifications for the various grades of platinum used in industry. Five grades of purity are recognised, as follows:—

(1) *Platinum A.* Physically pure platinum with a minimum standard of purity of 99.99 per cent.; used for thermocouples and resistance pyrometers. (2) *Platinum B.* Chemically pure platinum with a minimum standard of purity of 99.90 per cent.; used for electrodes. (3) *Platinum C.* Utensil platinum containing up to 0.3 per cent. iridium, other metals not exceeding 0.1 per cent.; minimum platinum content 99.7 per cent. (4) *Platinum D.* Technically pure platinum containing at least 99 per cent. platinum and not less than 99.5 per cent. of platinum metals. (5) *Platinum E.* Jewellery platinum containing not less than 95 per cent. platinum.

It should be noted that the highest quality of platinum is designated "physically pure" platinum, and is used where specific electrical properties are required. The purity of this grade of platinum is best determined either by a thermoelectric method or by measurement of the temperature coefficient of resistance. The thermoelectric method is stated to be more sensitive even than spectroscopic tests.[12] At the United States Bureau of Standards each batch of material is tested against a special standard (Pt. 27) which contains less than 1 part in 10^6 of impurity. In some cases the thermal e.m.f. against the standard Pt. 27 has been ffound to be as much as 50 microvolts at 1,200° C. when spectroscopic tests failed to show any impurity. The smallest amount of impurity which has been detected spectroscopically corresponds to a change in thermal e.m.f. at 1,200° C. of about 20 microvolts. In general, small amounts of impurity make it positive thermoelectrically to pure platinum.

Dissolved gases as well as metallic impurities have a marked effect on the thermoelectric properties. Sivil[2] records the case of a sample containing dissolved oxygen whose thermal e.m.f. was reduced from 4 microvolts to 1 microvolt by heating *in vacuo*. He also states that platinum melted in the atomic hydrogen torch gave at 1,200° C. an e.m.f. of 750 microvolts against a platinum standard.

The temperature coefficient of resistance between 0° and 100° C. is also a sensitive indication of purity. Physically pure platinum should have a value of the ratio $\frac{R_{100}}{R_0}$ of at least 1.390. The presence of 0.1 per cent. palladium will lower the value of this ratio to about 1.379 while 0.1 per cent. iron lowers it to 1.355[13]. Gerlach[3] has shown that the

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[1] H. St.-C. Deville and H. Debray, *Ann. Chim. Physique*, 1859, **56**, 385.
[2] C. S. Sivil, *Trans. Amer. Inst. Min. Met. Eng., Inst. Metals Div.*, 1931, 246.
[3] W. Gerlach and E. Riedl, *Physikal. Z.*, 1933, **34**, 516.
[4] E. M. Wise and J. T. Eash, *Trans. Amer. Inst. Min. Met. Eng.*, 1935, **117**, 313.
[6] A. Jedele, *Z. Metallkunde*, 1935, **27**, 271.
[7] W. H. Swanger, *Bur. Standards J. Research*, 1929, **3**, 1029.
[8] Messrs. Johnson Matthey, *Chem. News*, 1885, **51**, 71.
[9] N. W. Perry, *Chem. News*, 1885, 51, 1-5, 19-21, 31-33.
[10] F. Henning and H. T. Wensel, *Bur. Standards J. Research*, 1933, **10**, 809.
[11] W. H. Swanger, A.S.T.M. and A.S.M.E. Symposium on the Effect of Temperature on Metals, 1931, p. 610.
[12] F. R. Caldwell, *Bur. Standards J. Research*, 1933, **10**, 373.
[13] von W. Goedecke, *Festschrift zum funfzigjahrigen bestehen der Platinschmelze G. Siebert G.m.b.H. Hanau*, 1931, 72.

purest form of platinum prepared by Heraeus has a residual resistance between 4° and 1.35°. A scarcely 0.0003 of the resistance at 0° C. In the determination of the freezing point of platinum at the National Physical Laboratory, using fused thoria crucibles, Schofield[14] measured the value of $\frac{R_{100}}{R_0}$ before and after the freezing point determinations. In one example given the value decreased from 1.3919 to 1.3911, showing that very little contamination occurred. Physical methods for testing the purity of the other platinum metals are not so well developed.

The high-temperature properties of the platinum metals are of some general interest. For most high-temperature uses it is important that they should remain either of constant weight or of constant composition, and mechanical strength is usually a secondary consideration. Crookes[15] carried out some experiments on the loss in weight of the pure platinum metals when heated in air at 900° and 1,300° C. The least loss in weight is shown by rhodium, and this is closely followed by platinum. Palladium shows somewhat higher losses, while iridium and ruthenium lose weight very rapidly. Osmium was not included, presumably because of the poisonous nature of the volatile tetroxide, but it would have given by far the highest weight loss at 900° C. rhodium and platinum showed practically no weight loss. At 900° C. rhodium and platinum showed practically no weight loss even after prolonged heating, but palladium lost 0.18 per cent. in 30 hours and iridium 0.09 per cent. in 22 hours. Carter[16] has indicated that weight losses for wires heated electrically are greater than for wires heated externally, and that rhodium is more volatile than platinum at temperatures above 1,00° C.

Constancy of Weight for Crucibles

In analytical work the constancy in weight of platinum crucibles after ignition is essential, and this point has been carefully examined by the Bureau of Standards.[17] [18] Platinum crucibles are not often made of "physically pure" metal, and there may be present small amounts of iridium and rhodium and traces of iron. Below 900° C. the loss of weight on heating in all cases is negligible, and at lower temperatures there may even be a slight gain in weight due to the iron content diffusing to the surface and oxidising. At higher temperatures there is a definite loss in all cases as shown in Table I.

TABLE I.—*Approximate Loss in Weight mg./100 cm.²/hr. for Platinum Nearly Free from Iron.*

Temperature, ° C.	Paltinum containing : Pure Platinum.	1% Iridium.	2.5% Iridium.	8% Rhodium.
900 or less ..	0	0	0	0
1,000	0.08	0.30	0.57	0.07
1,200	0.81	1.2	2.5	0.54

Above 900° C., the loss in weight for iridium-containing platinum is very much greater than that of pure platinum, and increases with the iridium content and with temperature. Rhodium-containing material shows lower weight losses than pure platinum at all temperatures above 900° .C These observations indicate the desirability of using platinum free from all metals other than rhodium. The addition of rhodium is beneficial in that it lowers weight losses and moreover gives a more robust material. For general laboratory use the Bureau of Standards recommends a rhodium content of 3-3.5 per cent. A further example may be taken from the use of the 10 per cent. rhodium-platinum alloy gauzes for the catalytic oxidation of ammonia, where weight losses are again lower than for the pure platinum gauzes. In thermocouple work constancy of compopsition is important and the above remarks indicate why the platinum-rhodium alloys are superior to the platinum-iridium alloys.

The losses in weight of the platinum metals (other than palladium) on heating in air are probably due to the formation of volatile oxides. The evidence in the case of osmium, ruthenium, and iridium is quite definite, but it has often been doubted that the loss in weight of platinum and rhodium is due to the formation of volatile oxides. In the case of these two latter metals there is a negligible loss *in vacuo* or in hydrogen and nitrogen, and in an oxygen atmosphere the loss is proportional to the partial pressure of oxygen. This seems to be decisive evidence against a true volatilisation loss, and in favour of the view that volatile oxides are formed. Palladium shows a definite weight loss *in vacuo* and in the case of this metal true volatilisation probably occurs.

Platinum Group Alloys

The use of platinum for the resistance windings of high-temperature laboratory furnaces is well known. Pure platinum has some disadvantages, but it has been found that the alloy 80 per cent. platinum : 20 per cent. rhodium is much more satisfactory.[11] This alloy has a higher melting point than platinum, a higher specific resistance, lower temperature coefficient of resistance, lower rate of volatilisation, and less tendency to become brittle due to crystal growth.

The high reflectivity and silvery-white appearance of rhodium coupled with its nobility has led to the use of thin rhodium electrodeposits for the protection against tarnish of sterling silver ware, reflectors, and a multitude of trinkets made by the jewellery trade. The high density of platinum and platinum-iridium alloys coupled with high corrosion-resistance and good workability makes them suitable materials for constructing radium needles and tubes for the medical profession.

The most important platinum alloys are those used for the manufacture of fine jewellery. Owing to the difficulties of assay of platinum alloys, it has not be been found possible to evolve a scheme for hall-marking platinum jewellery, and at the present time most manufacturers adhere to a 950 standard which has been agreed to by all the important European countries. Iridium counts as platinum in this 950 standard. Base metals may be present in amounts up to 5 per cent. and two commonly used alloys contain 3 per cent. and 4.5 per cent. of copper, respectively.

The use of copper for hardening platinum follows the long-established trade custom of hardening the two precious metals gold and silver. In the case of platinum the use of base metals is quite unnecessary, since the quality of platinum goods could best be maintained by the use of alloys hardened solely with the other platinum metals such as iridium, rhodium and ruthenium. These alloys are superior in several respects to the copper-containing alloys. The highest quality platinum jewellery is made from 5 per cent. and 10 per cent. iridio-platinum. Other very high-grade alloys can be made with the addition of 5 per cent. rhodium plus ruthenium, the ruthenium content being varied according to the hardness required.

Catalytic Properties

The catalytic and corrosion-resistance properties of the platinum metals lead to their extensive use in the chemical industries. As regards catalytic reactions brief mention might be made of the use of gauzes of the alloy rhodium 10 : platinum 90 per cent. for the oxidation of ammonia in the production of nitric acid, and the use of finely divided platinum on a suitable carrier for the contact process of sulphuric acid manufacture. The corrosion-resistance of the platinum metals is made use of in chemical processes where the conditions are severe. As examples there may be mentioned spinnerets used in the artificial silk industry and anodes used for the manufacture of per-salts and oxidising agents.

[11] F. H. Schofield, *Proc. Roy. Soc.*, 1934, [A], 146, 792.
[15] Sir W. Crookes, *Proc. Roy. Soc.*, 1911-1912, [A], 86, 461.
[16] F. E. Carter. See discussion on paper Ref. No. 31 by W. H. Swanger.
[17] G. K. Burgess and P. D. Sale, *U.S. Bur. Stand. Sci Paper* No. 254, 1915.
[18] G. K. Burgess and R. G. Waltenburg, *U.S. Bur. Stand. Sci. Paper* No. 280, 1916.

Some Recent Metallurgical Patents

Lead Alloys

A PROCESS for treating alloys of lead and antimony containing at least 20 per cent. of antimony comprises forming a molten bath of the alloy, simultaneously agitating and lowering the temperature thereof and thereby concentrating the antimony as a dross which is treated with a drying agent to yield a dross containing 65 to 80 per cent. of antimony. The original temperature of the bath is within the range of 750° to 800° F. and is lowered at the rate of 15° to 25° F. per hour to 550° to 525° F. at which temperature the drying-agent, which may be petroleum coke or rosin or both, is added. The dross is removed by shovelling and the temperature of the bath lowered to 490° F. when a crust separates containing the excess of antimony over the eutectic ratios of lead and antimony (13 per cent. of antimony). The eutectic metal is removed and a fresh charge mixed with the crust. In addition to antimony and lead, the crude metal may contain tin, copper and arsenic. In an example, the crude metal comprised 30 to 35 per cent. of antimony, 1 to 2 per cent. of copper, 1 to 2 per cent. of arsenic, 0.2 per cent. of tin and 0.2 per cent. of tellurium and nickel, the balance being lead. Tin and arsenic may be removed by heating to approximately 1,000° F. under oxidising conditions. Alloys poor in antimony may be treated, as by smelting, to increase the antimony content before carrying out the present process. (See Specification No. 447,451, of American Smelting and Refining Co., and H. H. Monson.)

Pickling Metals

PHOSPHORIC acid pickling baths for ferrous metals are regenerated by adding sulphuric acid thereto. The amount of sulphuric acid is preferably smaller than that required to form ferrous sulphate with all the iron in solution and is added in small quantities at different times. Part of the exhausted bath, prior to regeneration, may be diluted and used as a second bath of acid iron phosphate to form a supporting film for paints or varnish. (See Specification No. 447,524, of Campagnie Nationale de Matieres Colorantes et Manufactures de Produits Chimiques du Nord Reunies Etablissements Kuhlmann.)

Cast Iron

CAST iron is produced by forming a charge containing a large proportion of cast iron scrap, *e.g.*, 50 per cent. or more, and bringing the molten iron into contact with silicon carbide in the presence of a substantial quantity of slag, *e.g.*, 5 per cent. by weight of metal in the charge, and thereby causing an exothermic reaction between the silicon carbide and the molten charge. The rest of the iron charge may consist of scrap or pig iron or a mixture of scrap and pig iron. The silicon carbide may be added to the charge in the cupola furnace where the charge is melted, and then a bed of coke is formed in the furnace, a layer of a slag forming ingredient such as limestone and then the charge of silicon carbide and iron is added. Alternatively the silicon carbide may be added to the molten iron tapped into a ladle from a cupola furnace. The silicon carbide may be in briquetted form or mixed with water to form a slurry or paste. (See Specification No. 447,539, of Carborundum Co., Ltd.)

High Density Alloys

MASSIVE bodies having a density greater than that of lead, particularly for use as shield against penetrating radiation, are made by heating a mixture of fine tungsten powder and the fine powder of another metal which may be copper or nickel to a temperature not exceeding 1,500° C. A binder such as a solution of wax in benzene may be used, such binder being removed during the heating process. Part of the shaping may be effected before the heating is completed. Compositions consisting of tungsten with (1) 5 per cent. of copper, (2) 5 per cent. of nickel, and (3) 5 per cent. of copper and 5 per cent. of nickel, are described. (See Specification No. 447,567, of General Electric Co., Ltd., and C. J. Smithells.)

Improving Alloy Steels

IN a process for improving the properties of austenitic alloy steels containing a precipitation hardening agent such as titanium or niobium, the alloy steel is quenched from a temperature above the recrystallisation to normal temperature, strain-hardened, *e.g.*, by cold working, and then subjected to a precipitation-hardening heat-treatment below the recrystallisation temperature. The precipitation-hardening temperature is carried out at 600° to 1,200° F., preferably at 850° F. for an alloy steel containing niobium, and may be of an hour's duration. The alloy steels treated may be chromium-nickel steels, chromium-nickel-managanese steels or chromium-manganese steels, and the content of titanium 0.2 to 1.0 per cent. and of niobium up to 3 per cent. In an example, an alloy steel treated contains 18 per cent. of chromium, 8 per cent. of nickel, not more than 0.2 per cent. of carbon and titanium 0.2 to 1.0 per cent., the latter content being preferably five times that of the carbon. Berryllium, copper, silicon and tantalum may also be used as precipitation hardening agents and in amounts up to 3 per cent. or a total of 3 per cent. when more than one is used. In an example, an alloy steel treated contains 18 per cent. of chromium, 8 per cent. of nickel, .05 per cent. of carbon, .40 per cent. of titanium, .03 per cent. of sulphur, .03 per cent. of phosphorus, .7 per cent. of manganese and .5 per cent. of silicon. (See Specification No. 447,606, of Goodyear Zeppelin Corporation.)

Tellurium Lead Alloys

IN a method of making lead-tellurium alloys, particularly for electric cable sheaths, 0.1 to 38 per cent. of tellurium, which may be in the form of the element or a compound, is introduced into molten lead, and the mixture is further heated so that the lead telluride formed dissolves in the lead; the product is then suddenly cooled and is thereafter heated with a further quantity of lead at a temperature not much above the melting point of lead. (See Specification No. 449,372, of Kabel und Metalwerke Neumeyer Akt.-Ges., and E. Kriner.)

Refining Metals

SELENIUM and tellurium are removed from non-ferrous metals, such as copper, by treating the fused metal with a mixture of one or more alkali compounds and one or more carbon-containing reducing agents, the treatment being carried out under non-oxidising conditions which are maintained as long as the metal is in contact with the slag. The metal may be treated with a mixture of soda and carbon, preferably fritted together, the mixture being blown into the molten metal or the molten metal being poured into a container on the bottom of which the mixture is placed. (See Specification No. 449,471, of O. Nielsen.)

Heat-Treating Light Alloys

A BATH for the heat-treatment of light alloys, containing magnesium at temperatures exceeding 275° C., consists of fused anhydrous sodium bichromate and/or fused anhydrous potassium bichromate. When both bichromates are used, the bath consists of 3 parts of sodium bichromate and 1 part of potassium bichromate. In an example, a magnesium alloy containing 8.5 per cent. of aluminium and 0.3 per cent. of manganese was heated in a bath consisting of 3 parts of fused anhydrous sodium bichromate and 1 part of fused anhydrous potassium bichromate at a temperature of 420° C., quenched and then heated for 2 hours in an annealing furnace at a temperature of 180° C. (See Specification No. 448,944, of I. G. Farbenindustrie.)

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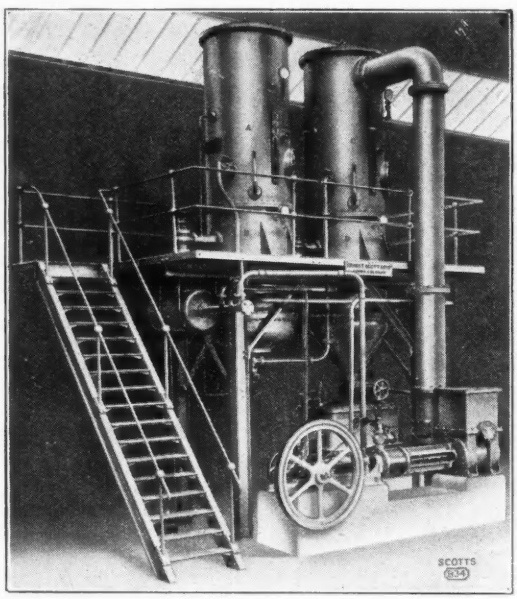

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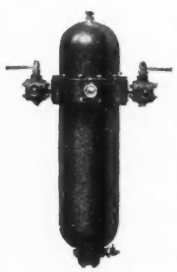

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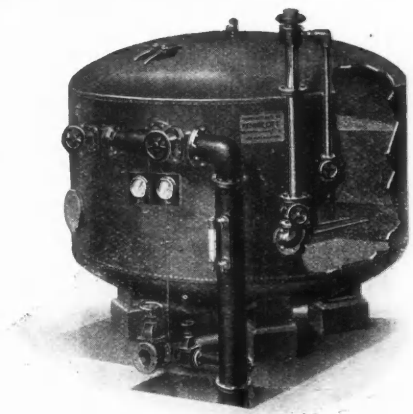

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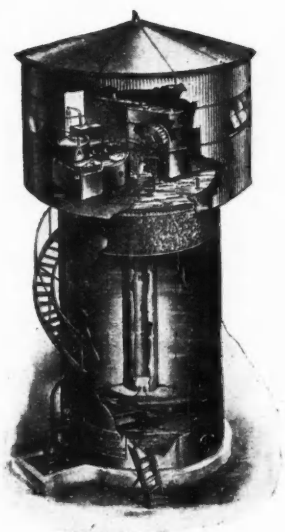

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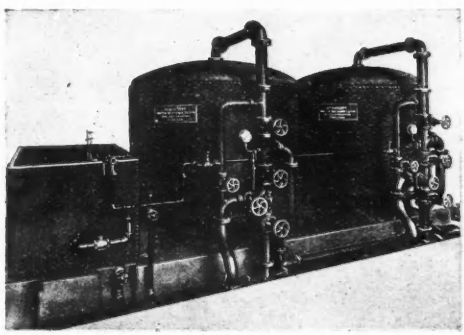

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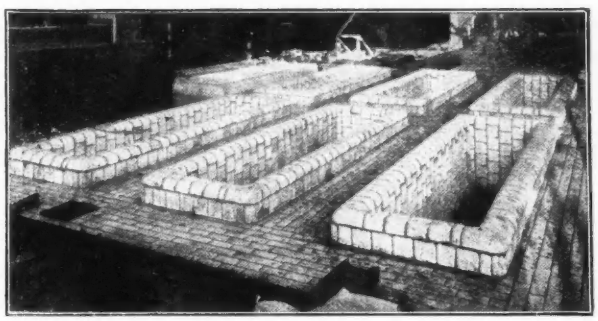

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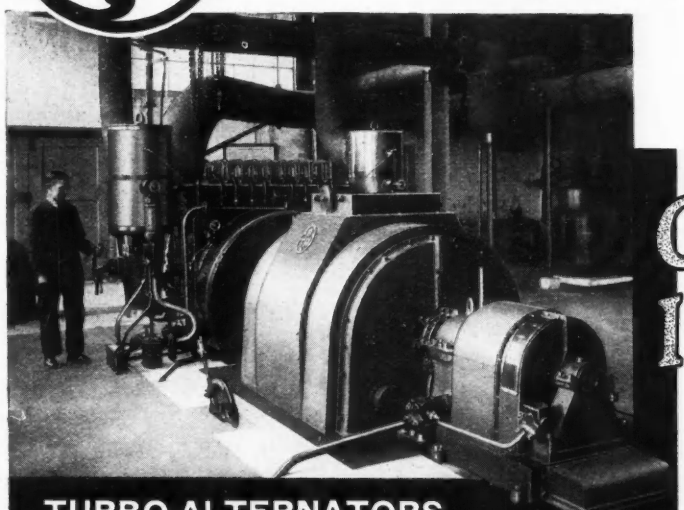

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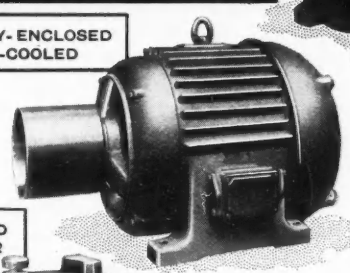

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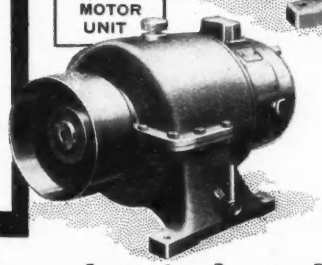

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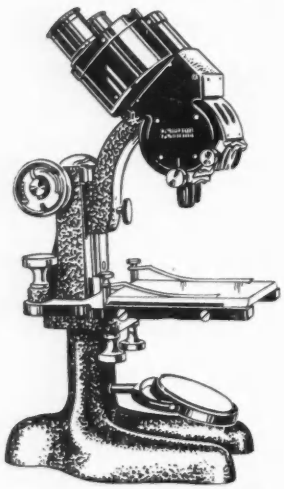

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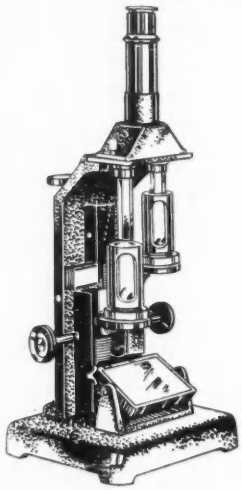

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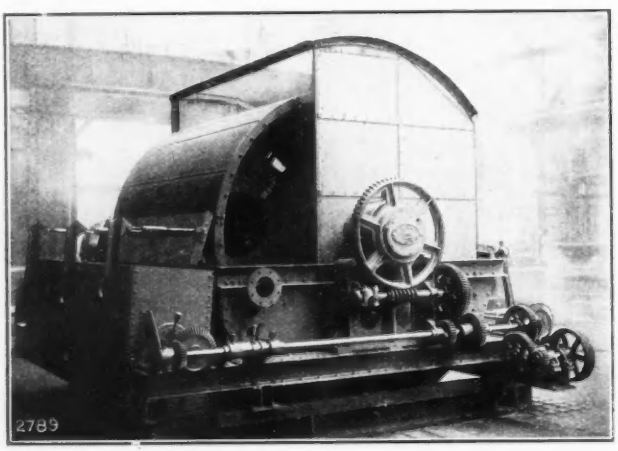

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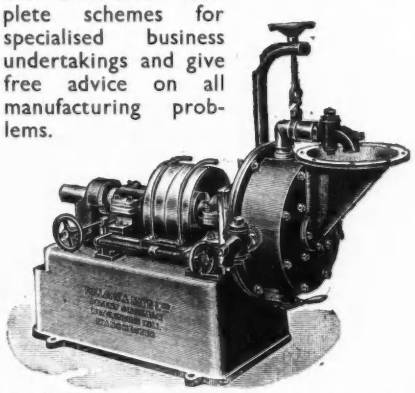

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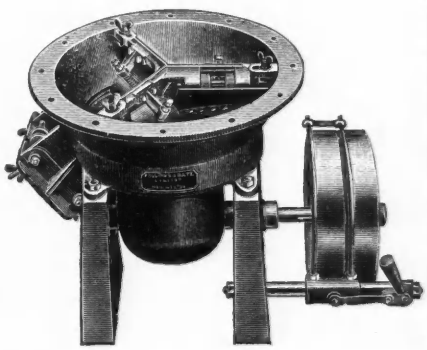

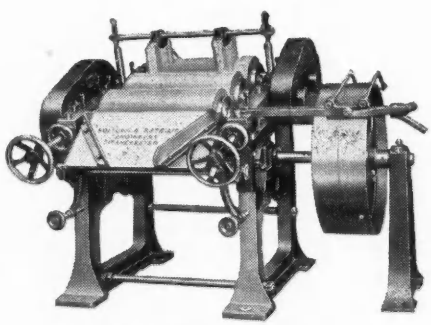

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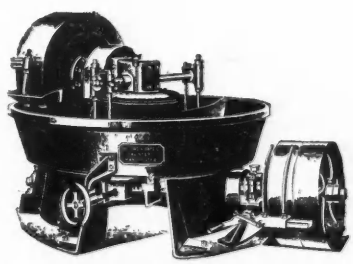

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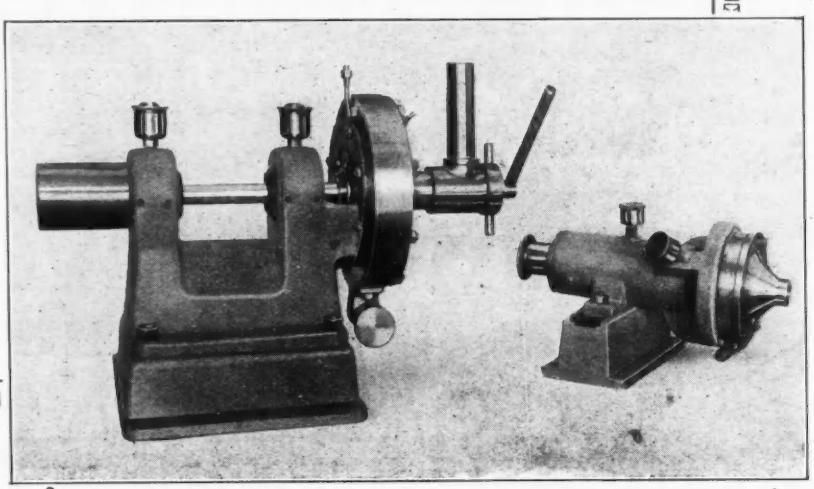

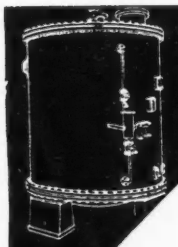

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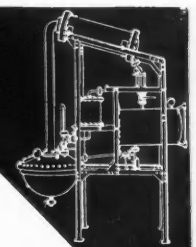

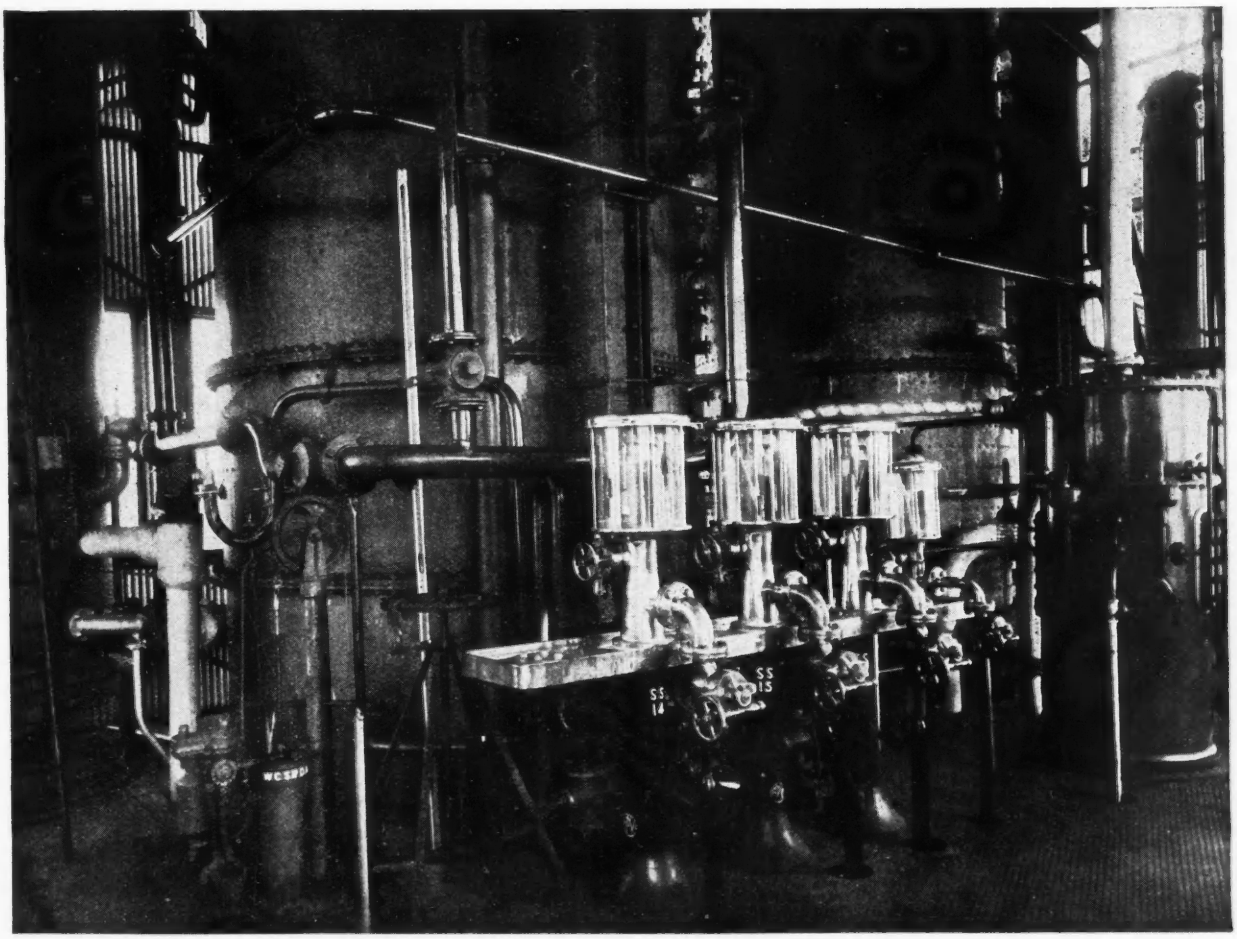

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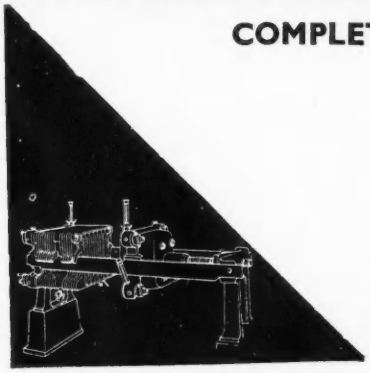

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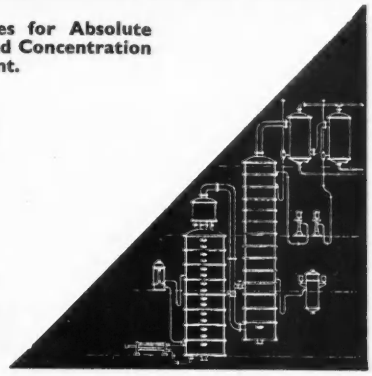

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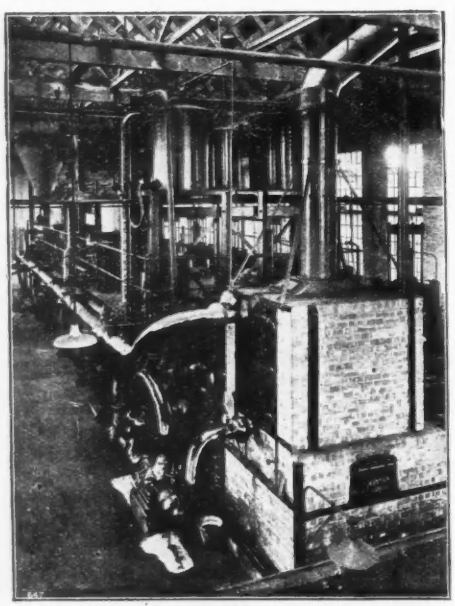

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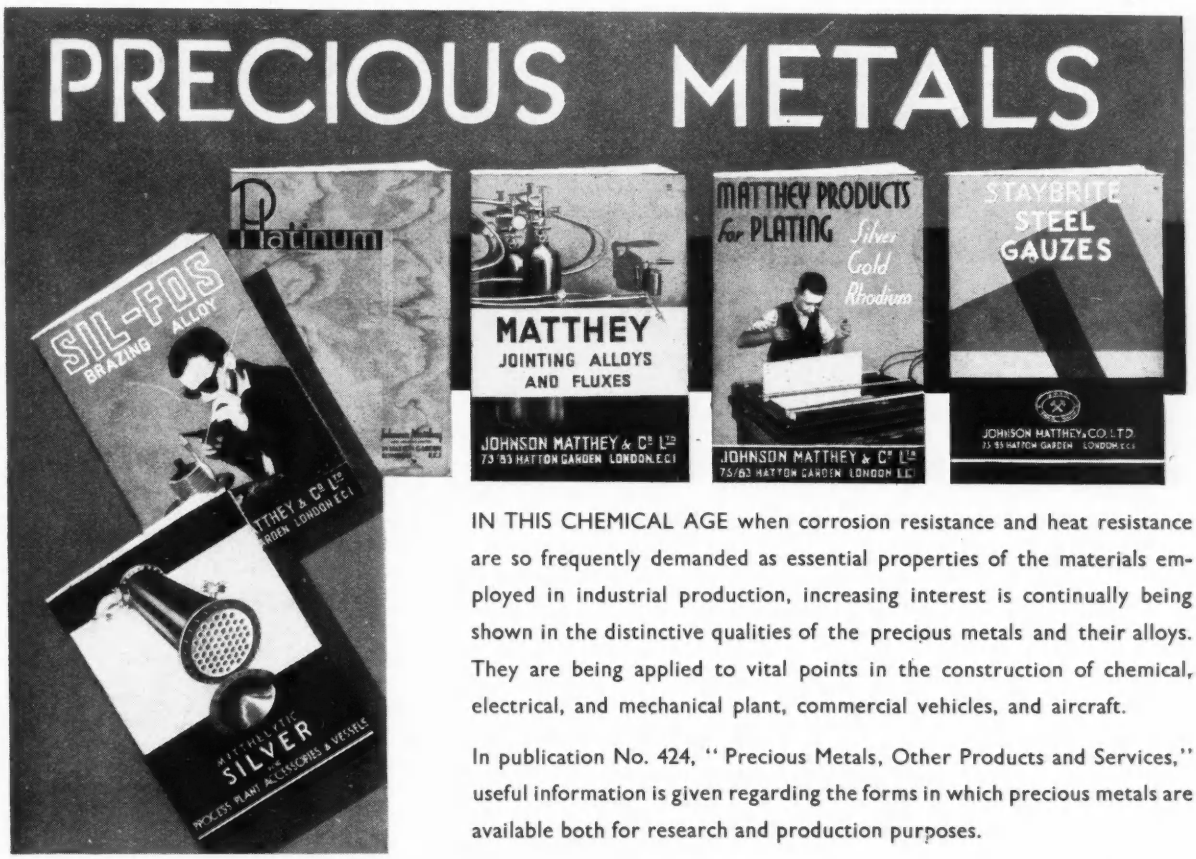

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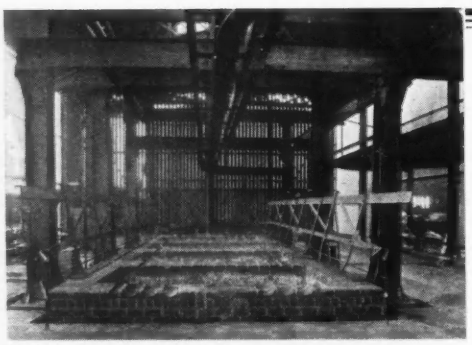

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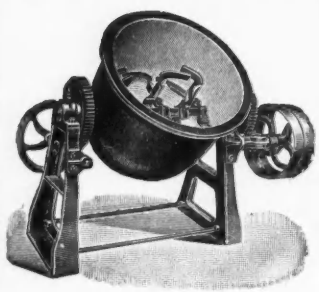

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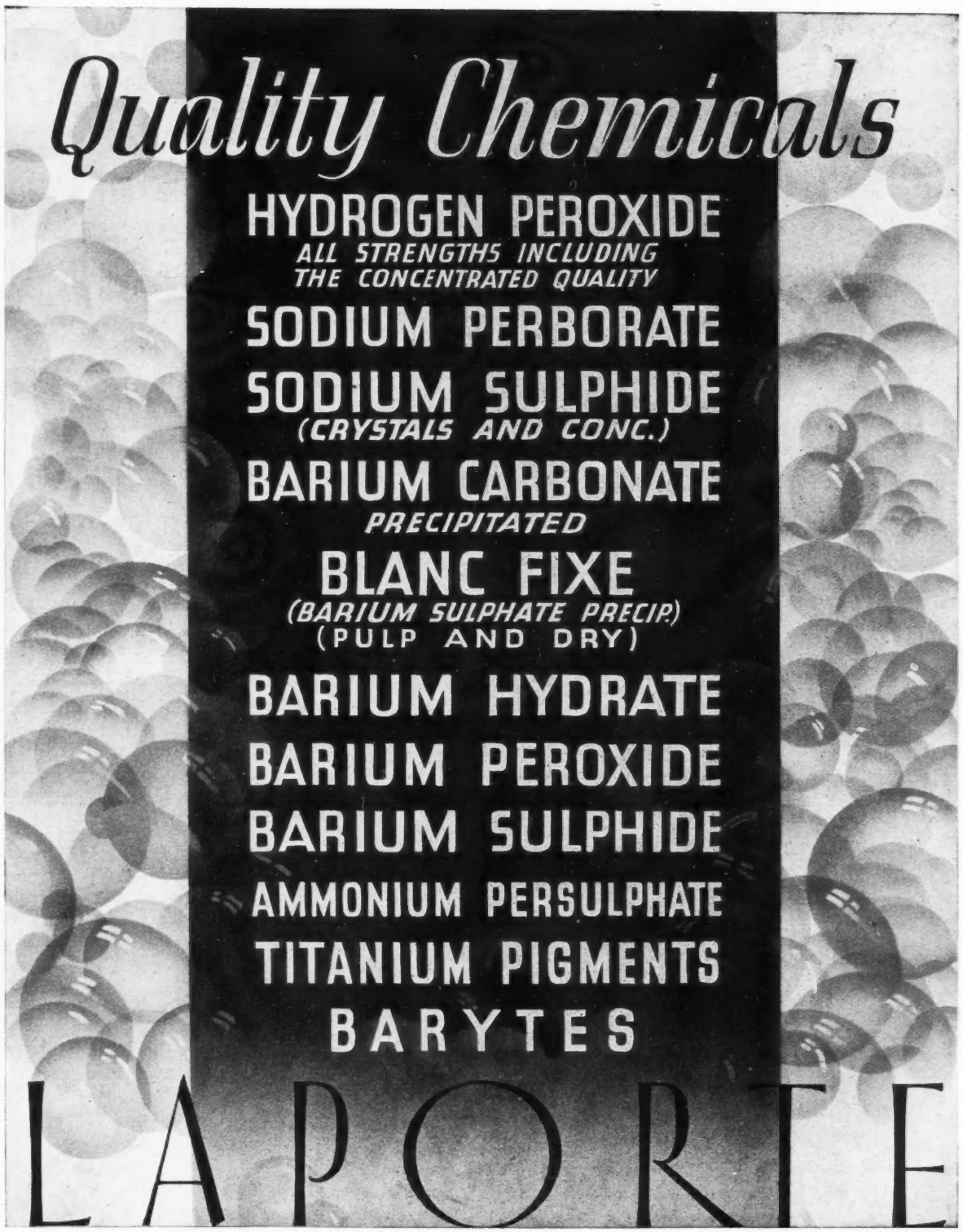

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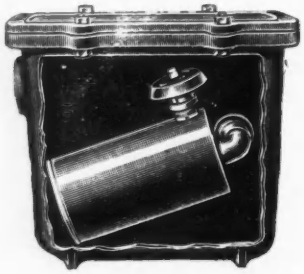
FLOAT  TYPE

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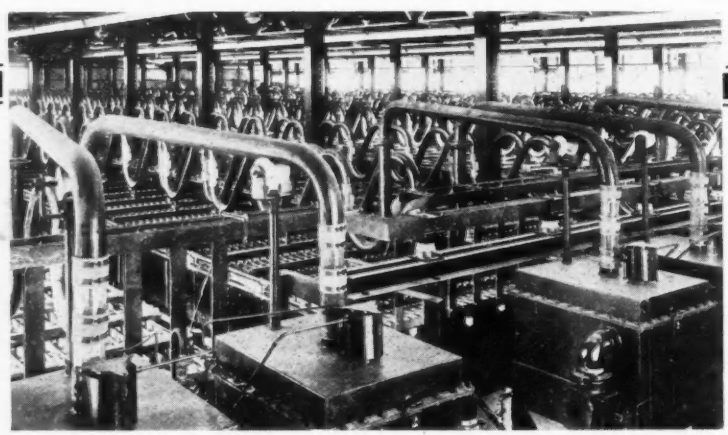

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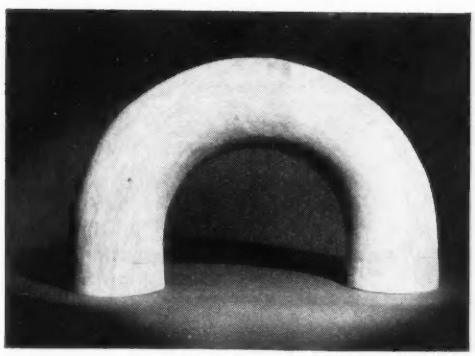

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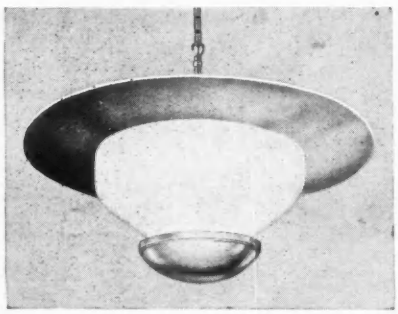

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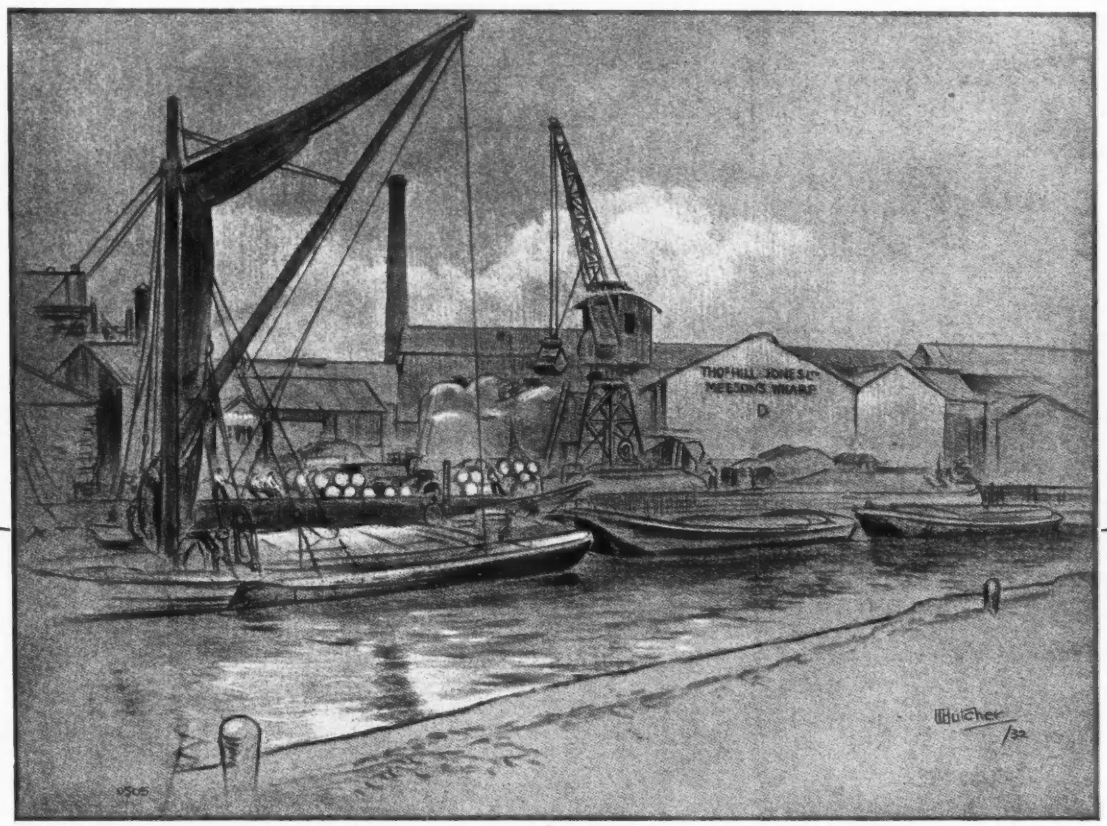

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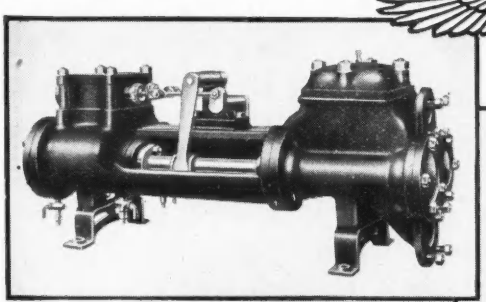

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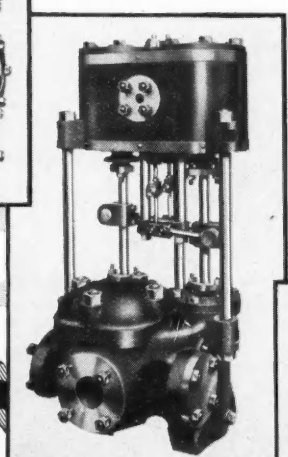

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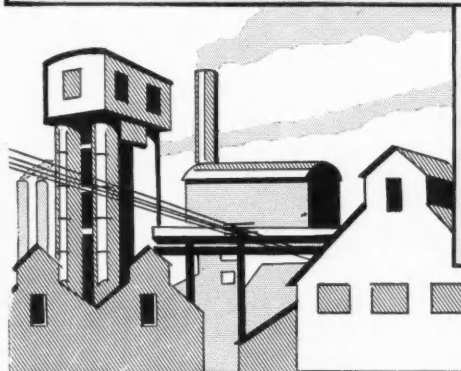

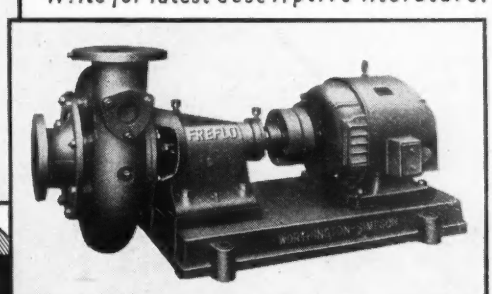

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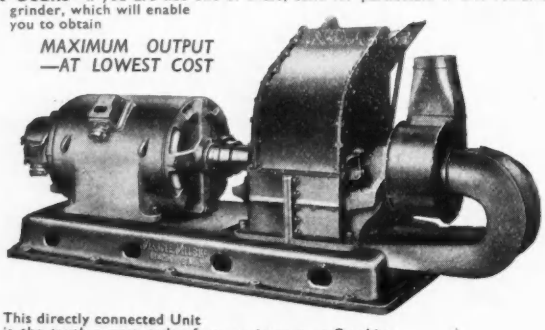

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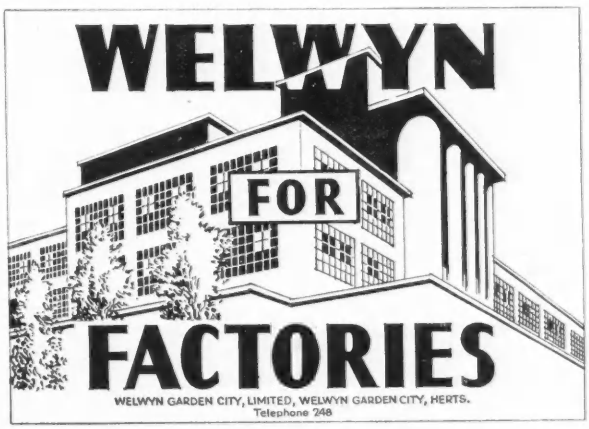

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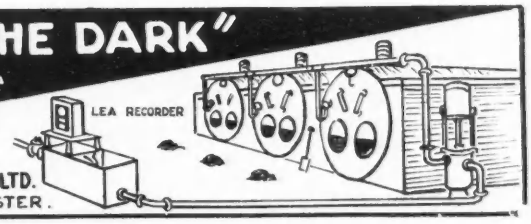

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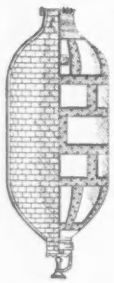

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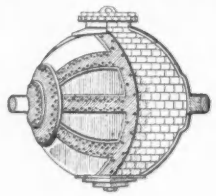

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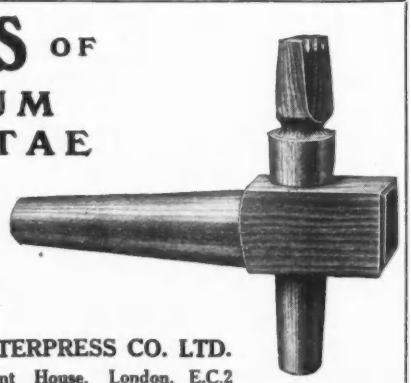

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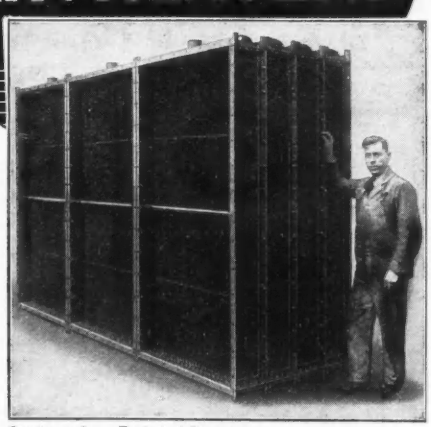

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